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CONTROL OF SEX AND SEX-LIMITED POLYMORPHISM IN THE HYMENOPTERA

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INTRODUCTION

THE efficient propagation and utilization of the Hymenoptera entails, in certain species, an artificial control of the sex ratio, a control long exercised in the case of domesticated mammals and birds. In the Hymenoptera, however, the control of the sex ratio is not limited to a differential mortality of the sexes: the sex of many hymenopterous insects can be predetermined. For many years predetermination of sex has been common practice with the beekeeper and insectary operator, contrary to the statement of Gowen and Nelson (1942), that in the past the sex of the offspring of any mating has been a matter of chance.

Sex determination is not necessarily purely genetic. Any factor, other than differential mortality, which predetermines the sex ratio is a sex-determining factor. Perhaps the geneticist needs to be reminded that the use of a lethal gene in manipulating the sex ratio is not a means of predetermining sex.

One hundred years ago, Dzierzon discovered that the male of the honeybee is produced uniparentally by the mated queen. It is this phenomenon that forms the basis of sex control in most species of the Hymenoptera. In such species every undeposited egg is potentially capable of either uniparental (male) or biparental (female) development. This accounts for the remarkable variations in the sex ratio of parasitic Hymenoptera. According to Clausen (1939), the sex ratio "will vary: (1) with the sex ratio of the host; (2) with successive generations upon the same or a different host generation; (3) with different hosts; (4) upon the same host and in the same season, but in different geographical regions; and (5) in successive years when the host population is increasing or declining rapidly."

In the Hymenoptera the control of sex involves also the control of polymorphism, since in many species, particularly the social forms, polymorphism is sex-limited. Such polymorphism is the basis of social organization as exemplified by the honeybee and the ant. It is the biological basis of the beekeeping industry.

The purpose of the present paper is to review the procedures for controlling the sex ratio and its correlated feature, polymorphism.

MECHANISMS OF SEX CONTROL

In the Hymenoptera there are two basic methods of controlling sex: one, through the modification of the primordial germ cells in the immature female, so that the egg after maturation is diploid (Flanders, 1944); the other, through the utilization of the sperms, stored in the gravid female, to change the sex of the undeposited ripe egg from male (haploid) to female (diploid).

Many species of Hymenoptera reproduce uniparentally; that is, all the females, as well as all

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the males, develop from unfertilized eggs. Such reproduction is known as amphitokous parthenogenesis (Wigglesworth, 1940).

The use of the term "parthenogenetic" in describing hymenopterous behavior is confusing. A parthenogenetic female may be either a female which was produced parthenogenetically, that is, uniparentally, and reproduces sexually; or a female which was produced sexually, that is, biparentally, and reproduces parthenogenetically. Mated, as well as unmated, females reproduce parthenogenetically. To state that the production of males by mated females is parthenogenetic is less exact than to state that such production is uniparental.

The writer (Flanders, 1945b) has demonstrated that, in the case of the chalcid *Habrolepis rouxi*, a uniparental parasite of the red scale (*Aonidiella aurantii*), the sex of the progeny of a female can be predetermined by manipulating the environment in which the female develops. Through the modification of the primordial germ cells, females can be obtained that produce only male progeny—females that otherwise would have produced only female progeny. (In such Hymenoptera each individual is obligatorily uniparental and therefore similar in reproduction to the cladocerans and aphids, in which each individual appears to be obligatorily either uniparental or biparental.)

Most species of Hymenoptera reproduce biparentally, however. In such species each individual is facultatively either biparental (female) or uniparental (male). Other animals that apparently belong in this category are certain species of rotifers, mites, white-flies, thrips, and the cottony-cushion scale (P. W. Whiting, 1945). In the propagation of such animals, the dominance of one sex is at the expense of the other, but without any reduction in total numbers. In most of the Hymenoptera which have been subjected to mass propagation, reproduction is of this type, the type, fortunately, that is most amenable to sex control.

In the mated hymenopterous female, the sperms stored in the spermatheca are completely quiescent, apparently inactivated by the slight amount of carbon dioxide present (Flanders, 1939). The few sperms at the opening of the spermatheca must be subjected to some activating agent before the egg can be fertilized. The source of such an agent appears to be the spermathecal gland, which presumably secretes a fluid that is slightly alkaline. The spermathecal gland apparently responds to environmental stimuli much as do the salivary glands in mammals. The capacity of the spermathecal gland to keep pace with the rate of egg deposition is probably an important factor in determining the sex ratio. The types of spermatheca represented in the Hymenoptera have been described by the writer in an earlier paper (Flanders, 1939).

Efficiency in the propagation of Hymenoptera is directly proportional to the extent of the substitution of females for males. Under insectary conditions, the proportion of females determines the reproduction rate of the population and the efficient use of the food supply. Under natural conditions, it is the female that searches for the food of its progeny and thereby ensures the increase of the population and the dispersion of the species. It is significant that in the field the normal female population, as pointed out by Clausen (1939), usually equals or exceeds the male population. This is effected in part by the shorter life of the male, and in part by the subjection of the female to factors that cause the deposition of a relatively high proportion of fertilized eggs. Under insectary conditions, however, the proportion of females is likely to be considerably less than in the field. In fact, in the case of certain species, male production greatly exceeds female production. Clausen (1939) states that the proportion of females may decline in successive generations, until the stock is lost.

Population density (of host as well as parasite) is the extrinsic basis of sex control in those species in which the sex of the individual is facultative. This is clearly demonstrated in the propagation of the parasitic Hymenoptera. Host density, in determining the size, availability, and attractiveness of the individual host, directly affects the sex ratio of the parasite. Host density, in determining parasite distribution and density, determines the time and frequency of parasite mating and therefore indirectly affects the sex ratio of the parasite.

Differential mortality during development

In gregarious species superparasitism, which usually takes place when hosts are relatively scarce, may cause an excess of males. A selective elimination of the female occurs probably because of the ability of the male to attain maturity on less

food than the female (Vandel, 1932). This ability of the male may be a factor in limiting polymorphic differentiation to the female sex.

In solitary species, the male may fail to survive if it inhabits a large host and is unable to consume the amount of host tissue necessary to render the host habitable during the pupal period of the male parasite. In such a case, when hosts are relatively scarce, the females rather than the males may predominate, since the individual host is likely to attain its maximum size when the density of the host population is low.

In this connection it should be noted that the exposure of a population to temperatures of about 3° C. during the pupal period of development may cause a differential mortality of the germ cells, the following generation consisting largely of males. Presumably, this was the case in *Trichogramma*, as reported by Schread and Garman (1933), and in *Tetrastichus*, as reported by the writer (Flanders, 1938).

Premating interval following emergence

In the propagation of biparental species, the insectary operator attempts to bring about the mating of all the females with a minimum number of males. The females of certain species are multinuptial, mating several times; those of other species are uninuptial. Mating in most of the species normally occurs soon after the emergence of the adult, and before oviposition begins. If hosts are abundant and males are scarce, the highest proportion of males can be expected to occur in the following generation. If mating is delayed for several days, the females of some of the species, such as those of *Pachycrepoideus dubius*, do not respond to mating stimuli, and all progeny are accordingly male (Crandell, 1939).

In many hymenopterous species, mating is a prerequisite of normal oviposition. In the case of *Melittobia chalybii*, normal oviposition is stimulated by mating with males of its own species or of a different species. The fertilized eggs from the abnormal mating do not hatch, however (Schmieder, 1938). It is significant that the inclination to oviposit readily only after mating is characteristic of species in which the female is polymorphic. In *Melittobia chalybii* both sexes exhibit polymorphism (Schmieder, 1933). In the social species, polymorphism is limited to the females.

In species that oviposit readily before mating, such as *Trichogramma*, *Microbracon*, and *Macrocentrus*, females may be less fecund after mating than before. Lund (1938) found this to be the case in *Trichogramma evanescens*. Inbreeding may accentuate this tendency in *Microbracon* (Flanders, 1943a; P. W. Whiting, 1940).

The females of *Macrocentrus*, under conditions optimum for reproduction, mate only once. When the newly emerged female meets the male frequently, however, and more than one mating occurs, she is in condition for repeated matings. This is likely to occur in the laboratory but not in the field, where the normal sex ratio is 2 males to 3 females (Holloway, 1934). In the laboratories of the University of California Agricultural Experiment Station, where, during the summer, a quarter of a million individuals are produced daily, the sex ratio at one time was highly variable, with a predominance of males, often in the ratio of 10 males to 1 female. Experiments by the writer were therefore undertaken to determine the conditions affecting the sex ratio in this species, and it was found that once-mated females, when isolated with an abundance of hosts, produced progeny that were predominantly female. The offspring of one female, for example, consisted of 284 females and 58 males.

A satisfactory sex ratio, with females predominant, is now being attained under abnormally high population densities by reducing the frequency of mating contacts through a reduction in light intensity. Sufficient time must elapse, however, between the emergence of adults and their collection for use in parasitization, to permit the mating of all females.

The *Macrocentrus* female, at each mating, receives a spermatophore from the male. After the spermatophore is adjusted so that it makes contact with the opening of the spermatheca and sperms have begun to move into the sperm capsule, a second mating rarely if ever takes place. Females that mate before this adjustment is completed will mate many times. They may receive so many spermatophores that none become adjusted and all are discarded before the female becomes impregnated. Multiple mating prolongs the preoviposition period and results in the

production of progeny predominantly male (Flanders, 1945c).

Differential in oviposition responses before and after mating

It is evident that the act of mating or the presence of sperms in the spermatheca has a marked effect on the psychology of the female. As pointed out by Wigglesworth (1940), the gonads of insects have little if any influence on mating. According to Whiting (1943), the mating reactions of *Microbracon* (*Habrobracon*) are determined in the brain.

In certain species of the Aphelinidae, mating has a remarkable psychological effect in that it causes a marked change in the type of host selected and the manner of oviposition (Flanders, 1937, 1943b). *Coccophagus cowperi*, for example, when unmated, oviposits only hyperparasitically on a host which is suitable for the development of the male but not of the female; after mating, it oviposits only as a primary parasite on a host which is suitable for the development of the female but not of the male. The hosts of the male and of the female belong to different insect orders. Mating reduces fecundity to the extent of the number of unfertilized eggs deposited in hosts in which the male cannot develop. In mass propagation, the sex ratio of *C. cowperi* is regulated by the ratio of its two host types. When unmated females of *C. cowperi* are used to parasitize the prepupae of *Leptomastix dactylopii* inhabiting the citrus mealybug, we obtain a pure culture of male parasites. After the females are mated and then used to parasitize black scale, a pure culture of female parasites is obtained. In this species, unlike most species of biparental Hymenoptera, oviposition prior to mating is necessary for the continued existence of the species.

Preferential oviposition sites

Clausen (1939) has summarized the published data showing that a change in host density is reflected in the size of the individual host and consequently in the sex ratio of the parasite. Large hosts are conducive to the production of female parasites, small hosts to the production of male parasites. This is an effect of the preferential character of the large hosts, such hosts apparently exciting the operation of the spermathecal gland and thus effecting the fertilization of the parasitic egg.

Microplectron fuscipennis, a gregarious species parasitic on the spruce sawfly, shows a definite preference for large hosts. Unfertilized (male) eggs of this species are deposited on small hosts, even when the latter are of a size to bring to maturity the total offspring of one parasitic female (Ullyett, 1936).

Brunson (1937) demonstrated that the females of *Tiphia popilliavora*, a species parasitic on the Japanese beetle, show a definite preference for large (third-instar) host larvae. This was shown by the proportion of eggs fertilized. When the preferred size is lacking, oviposition occurs readily on small larvae.

In the mass propagation of the black-scale parasite *Metaphycus helvolus*, the writer observed that the proportion of females increases directly with the size of the hosts attacked. Oviposition occurs in hosts ranging from 0.6 mm. to 2.5 mm. in diameter (Flanders, 1942b).

In the highly organized colony of the honeybee, we have an excellent demonstration of preferential oviposition. Grout (1937) has shown that when the queen honeybee has an opportunity to choose between cells of different sizes as sites for the deposition of her eggs, cell size influences the activation of the sperms and the fertilization of the egg. The queen prefers to oviposit in cells of normal brood size, and the eggs deposited in such cells are consequently almost always fertilized. A young, inexperienced queen, however, given no opportunity to show preference, will deposit fertilized eggs in cells of abnormal size. Grout also observed that the queen honeybee tends to deposit a greater proportion of fertilized eggs in new cells than in old, used cells. The number of male (drone) cells constructed in a hive increases with the density of the hive population. Drone cells are usually formed in small groups among the smaller female (worker) cells. The beekeeper determines the sex of the honeybee brood by providing cell foundations of proper size and by controlling the density of the population in the hive.

In colonies of vespoid wasps, however, the unfertilized eggs are deposited indiscriminately in small and large cells. Since the ovipositing female is, as a rule, supplied with an excess amount of sperm, the deposition of unfertilized eggs is probably an effect of the rate at which the eggs are deposited. The spermathecal gland may not

secrete the sperm-activating fluid at a rate which will enable the sperms to contact every egg.

Rate of oviposition

A number of observations by different workers indicate that the rate of egg deposition is an important factor in determining the sex ratio, and, in some social species, in limiting polymorphism to the female sex.

With the egg parasite *Trichogramma*, the usual sex ratio is one male to two females. This ratio apparently is an effect of the female's habit of depositing three eggs in rapid succession during one insertion of the ovipositor. The first egg to move down the ovipositor is fertilized (female), the second egg is usually fertilized (female), and the third is unfertilized (male). This was determined by the writer (Flanders, 1935), using hosts that permit the development of 1 to 10 parasites per host. Each of 69 mated females of *Trichogramma* was isolated in a gelatin capsule containing one host egg. Thirty-eight of the females were removed from the capsules before or immediately after the withdrawal of the ovipositor from the host. Their progeny were allowed to mature and emerge in the capsules. Twelve capsules contained abnormally large females, one in each capsule, indicating that the parent females had deposited only one egg per host. Seven capsules contained somewhat smaller females, two in each capsule, indicating that the parent females had deposited only two eggs per host. Eighteen capsules contained normal-sized females and males, two females and one male per capsule, indicating that the parent females had deposited three eggs per host. One capsule contained one male and one female, an exception that proves the rule. The sex ratio of *Trichogramma* is likely to be about the same in the laboratory as in the field.

The oviposition responses of the female to host density, however, may be affected by temperature. Lund (1938) makes the interesting observation that mated *Trichogramma* which had undergone development at temperatures of about 15° C. exhibited extreme activity when held at about 25°C. Such females deposited more unfertilized than fertilized eggs. Hanna (1935), in the case of *Euchalcidia caryobori*, noted that the progeny of parents that had been exposed to a temperature of 16° C. during the pupal stage, consisted largely of males. Possibly in this case the sex ratio was affected by the extreme activity of the adults.

Leiby (1926) was one of the first to suggest that fertilization of the egg was regulated by the rate of oviposition. He found that when the mated female of the polyembryonic *Copidosoma truncatellum* deposits two eggs at one insertion of the ovipositor, the second egg is without sperm in at least 80 per cent of the instances. *Eggs were rarely deposited singly without a sperm.* Powell (1938), likewise, observed that in the case of the ectoparasitic vespoid wasp *Cephalonomia tarsalis*, which normally deposits its eggs in pairs, the first egg is fertilized and the second unfertilized.

The writer has observed that the black-scale parasite *Coccophagus ochraceus*, which attacks very young hosts, may deposit about a dozen eggs in rapid succession if hosts are abundant. The first egg is fertilized and is deposited within the body fluids of a scale insect; the remaining eggs of the clutch are unfertilized and are deposited externally under other scales, the immature female being an endoparasite and the male an ectoparasite of the same host species (Flanders, 1942a). The sex ratio of *C. ochraceus* is subject to manipulation through regulation of the host density, the external factor which as a rule determines the rate of egg deposition and the sex of the deposited egg.

It is obvious that sex ratios of endoparasites which deposit only one egg with each insertion of the ovipositor are more susceptible to manipulation than those of endoparasites which deposit a number of eggs with each insertion. Sex ratios of solitary ectoparasites are also more susceptible to manipulation than those of gregarious ectoparasites.

Under insectary conditions where hosts are abundant and so readily available that little time is spent in searching, it is more difficult to obtain natural sex ratios with solitary species than with gregarious species. Bradley and Burgess (1934), in their study of the solitary species *Cremastus flavoorbitalis*, a parasite of the European corn borer, found that the sex ratio of field-collected material was approximately two females to one male, whereas under laboratory conditions the progeny of mated females were approximately in the ratio of one female to two males. Ford (1943) reared various species of *Apanteles* from extensive field-collected material and noted that equal numbers of each sex occurred in solitary species, whereas males predominated in gregarious species. This may be an effect of a higher rate of egg de-

position in the gregarious species than in the solitary species.

Differential in the polyembryonic proclivity of the sexes

Recently, in the mass propagation of the polyembryonic encyrtid *Copidosoma koehleri* on the potato tuber moth, the writer noted that, on the average, about twice as many females as males developed per individual host. Usually every brood, that is, all the individual parasites developing in any one host, is either entirely male or entirely female, with the female broods containing the maximum number of individuals and the male broods the minimum. In the occasional mixed brood (which occurs when one fertilized and one unfertilized egg are deposited in a single host), the females usually outnumber the males, sometimes by a ratio of 23 to 1. It is evident that in this species, as in other polyembryonic Hymenoptera, the female is more polyembryonic than the male (Flanders, 1942b).

The general predominance of females in this species, *when hosts are abundant*, indicates that the sex ratio is influenced largely by the amount of oviposition before mating and by the polyembryonic proclivity of the female.

SEX-LIMITED POLYMORPHISM

Polymorphism, or the existence within a species of two or more adult forms of the same sex, is characteristic of many insects. In the Hymenoptera, polymorphism appears to be an effect of nutritional differences occurring during ontogeny. The degree of polymorphic differentiation apparently varies with the developmental stage in which differentiation is induced. That induced during the larval stage, as in the honeybee and the parasite *Melittobia chalybii*, is much less marked than that induced earlier in development, during the primordial germ-cell stage, as is apparently the case in the alternating generations of the gall wasps (Cynipidae).

Polymorphism plays an important part in the economy of a species when it forms the basis of a social organization, as in the aculeate Hymenoptera and the Isoptera (Termitidae). In the Hymenoptera, however, the occurrence of polymorphism is limited by haploidy, a phenomenon unknown in the Isoptera, in which the sexes are diploid and equally polymorphic. In the Hymenoptera, only the female is normally diploid, and polymorphism is largely limited to that sex. Such a limitation, however, is not because haploidy in itself is inimical to polymorphism. Species exist in which polymorphism is limited to the haploid male (Salt, 1941; Costa Lima, 1943)—species which are endoparasitic, so that the embryo is in a position to obtain nourishment from the host. The males of *Trichogramma semblidis* are winged when their development takes place in the eggs of *Ephestia kuehniella*, and wingless when their development takes place in the eggs of *Sialis lutaria*. No intermediate forms occur, although the dimorphism appears to be an effect of a qualitative difference in nourishment.

The relatively low incidence of male polymorphism in most hymenopterous species may result because the haploid male is not subjected to the conditions which cause polymorphic differentiation. Apparently, the castes of the social Hymenoptera are female either because the haploid male is rarely if ever undernourished during development, or because most, if not all, of the eggs subjected to the oosorptive process while in the ovary are fertilized when deposited.

Haploidy, however, is reported to be lethal under certain conditions in several species of parasitic Hymenoptera, non-polymorphic as well as polymorphic (McColloch and Yuasa, 1914; MacGill, 1923; Schmieder, 1938). It is significant that in these species the gravid female shows a disinclination to oviposit before mating. In most species that oviposit as readily before mating as afterward, haploidy is rarely if ever a factor in the failure of the eggs to hatch. It is evident, therefore, that haploidy may be lethal only if it is associated with some condition of the egg brought about by the disinclination to oviposit.

Most of the Hymenoptera are highly specialized in their selection of sites for the deposition of their eggs. Consequently, it is not surprising that in many species of Hymenoptera, particularly in those in which the female is long-lived, oosorption occurs if suitable oviposition sites are lacking.

When the rate of egg deposition is relatively low, a relatively high proportion of the eggs deposited may have been partially absorbed (Weyer, 1928; Anna R. Whiting, 1940). In the mated female such eggs are more likely to be fertilized than those deposited rapidly and not subjected to the oosorptive process.

In social species, therefore, the low incidence of male polymorphism may result either from the

mortality of the partially absorbed unfertilized egg, from the fertilization of all the partially absorbed eggs deposited, or from the relatively small nutritional needs of the haploid form.

With the honeybee and the wasps, the castes are determined post-embryonically; with the bee *Melipona* and the ants, they are probably determined during the embryonic stage of development (Flanders, 1945a). The castes of the ant, in which it appears that differentiation is determined partly by the partial absorption of the ripe ovarian egg (a point possibly midway in the development of the individual), should be more strongly differentiated than queen bee and worker, and less so than the alternating generations of gall wasps. The oosorptive process is likely to have a graduated effect on the eggs, which would allow for the fullest expression of the polymorphic potentialities inherent in the germ plasm. In the case of the honeybee, the hatching of the egg is supposedly dependent upon the worker's provisioning the cell with liquid food. The fact that more non-hatching eggs are deposited by unmated than by mated queens indicates that it is the partially absorbed egg that remains unfed.

Influence of embryonic nutrition

In the colonies of certain social Hymenoptera, the rate of egg deposition may be correlated with the ratio of castes, as well as of sexes. This is indicated in the seasonal behavior of the bee *Halictus malachurus*, as observed by Stöckhert (Wheeler, 1933). This bee nests in hard, clayey soil, often in congregations of more than a thousand burrows. In each burrow there is an overwintering female that had mated the previous fall. In the spring the female constructs a cluster of brood cells off the main gallery, provisions them, and deposits an egg in each. Each cell is closed after oviposition. During the summer all the eggs develop into female workers, smaller than the mother and differently sculptured. The worker, during its short life of 4 to 6 weeks, is very active, foraging for pollen to provision the nest. The number of workers increases until August, when there are about a dozen in each nest. In July the overwintering female begins to deposit eggs that develop into short-lived males and into fall-type females which overwinter. These fall-type females are very lethargic, compared with the summer-type females. The males mate only with the fall-type females. The old overwintering female which produced the males and females of the summer and fall types lives until the end of the season, still with ripe eggs in the ovary and an abundance of sperms in the spermatheca.

Since *all* the eggs deposited early in the season, and only a part of those deposited later, are fertilized, it is probable that the early-produced eggs are deposited more slowly than those deposited later. The slow rate of deposition of the early-produced eggs insures the fertilization of each, but exposes them to the process of oosorption, a process which maintains a constant number of ripe eggs in the ovary when environmental conditions inhibit oviposition (Flanders, 1942c). As the number of workers increases and the food supply increases and temperatures become higher, the old mother presumably deposits eggs so rapidly that all of them escape the effect of oosorption and a portion escape fertilization, so that the males and the fall-type females appear.

The structural differences between the summer-type and fall-type females may be an effect of the oosorption process on the early-deposited eggs, rather than of a nutritional difference after hatching, as in the honeybee. Eggs deposited slowly because of retention in the ovary are more likely to have been subjected to the processes of oosorption than eggs deposited as rapidly as they ripen. It may well be, therefore, that the eggs deposited early in the season are deficient in the nutritive materials required for the embryonic development of the fall-type female.

It is significant that Goetsch (1939) found that the ant *Pheidole pallidula* deposits small eggs which develop into a distinct caste of small, short-lived workers, and large eggs which develop into large workers, soldiers, and, *when the queen is old and nurses are numerous* (conditions conducive to rapid egg deposition), into males and queens.

In the wasps and ants, as well as in the bees, *Halictus* and *Melipona*, the egg that gives rise to a male is, during its ontogeny, rarely if ever subjected to the oosorption process, since the male's existence is apparently dependent upon a high rate of egg deposition. In the honeybee, however, the occurrence of the male is also dependent on the preferential response of the queen to the two sizes of cells in which the eggs are deposited. When the rate of oviposition is high, queens lacking the capacity for preferential oviposition are likely to have mostly male offspring.

Influence of post-embryonic nutrition

Unfertilized (drone) eggs of the honeybee are deposited as a rule in cells somewhat larger than worker cells. Drones, however, also develop successfully from unfertilized eggs placed artificially in worker cells (Grout, 1937). Unfertilized (male) eggs of the wasps are deposited naturally in the small, worker cells, as well as in the large, queen cells. Since functional males can develop in small cells as well as in large ones, it is evident that the nutritional requirements for the complete development of the sexual form are considerably less for the male than for the female.

Haydak (1943) is of the opinion that the polymorphism of the female honeybee is an effect of the amount, and not of the quality, of food consumed during the larval period. There is no underfeeding of the queen at any time during the larval life, whereas with the worker a partial inanition starts after the larva attains the age of about 2.5 days. This change in the case of the worker larvae is an effect of the small size of the cell. In such cells the larvae over 2.5 days old are so large in relation to the cell size that the mass type of feeding, which is no longer possible, is replaced by the progressive type of feeding. Haydak postulates that the manifest differences between the worker and the queen are the result of differences in the amount of hormone material secreted by the well-nourished organs of the queen and by the starved organs of the worker. The influence of cell size on the course of female development is utilized commercially by breeders of queen bees.

SUMMARY

In the mass propagation of Hymenoptera, efficiency in reproduction is directly proportional to the extent of the substitution of females for males. Artificial control of sex and sex-limited polymorphism has been achieved, for example, in the honeybee and in certain parasitic Hymenoptera.

There are two methods of controlling sex in the Hymenoptera: one, through modification of the primordial germ cells in the immature female; the other, through utilization of sperms to change the sex of the undeposited ripe egg from male to female.

Sex ratios are determined *extrinsically* by the effect of the density of oviposition sites (hosts) on (a) differential mortality during development; (b) the premating interval after emergence, which determines the proportion of eggs deposited before mating and the inhibition of mating; (c) excessive mating; (d) the differential in oviposition response before and after mating; (e) the occurrence of preferred oviposition sites; and (f) the rate of oviposition. Sex ratios are determined *intrinsically* by (a) the number of eggs deposited at one insertion of the ovipositor, (b) the number of ovarian eggs ready for deposition, and (c) the differential in the polyembryonic proclivity of the sexes.

Polymorphism is limited *to the female sex* by the restriction of oviposition to mated females, so that all eggs that are deposited so slowly as to be subjected to the oosorptive process in the ovary are fertilized (possibly in the bees *Halictus* sp. and *Melipona* sp., and in all ants); and by the relatively small nutritional requirements of haploid larvae (in honeybees and wasps). Polymorphism is limited *to the male sex* by the susceptibility of the male to qualitative differences in hosts, as in the case of *Trichogramma semblidis*.

Eggs subjected to the oosorption process may not develop, if unfertilized before deposition.

It appears that the caste ratios in social Hymenoptera may be controlled post-embryonically by regulation of the ratios of brood cells of different sizes and thus of the amount of food consumed, and embryonically by regulation of the rate of egg deposition and thus of the exposure of the ripe ovarian egg to the process of oosorption.

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PREDATION AND VERTEBRATE POPULATIONS

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WHATEVER else may be said of predation, it does draw attention; and the literature dealing more or less directly with the subject surely numbers many thousands of titles. Much space in technical and popular writings, alike, has been devoted to the food habits of predatory species, and much has been written about prey species suffering or being relieved from predation. The population significance of predation mortality, however, has seldom received critical treatment.

Few even of scholarly discussions of predation upon vertebrates are adequately supported by quantitative data. Fewer are without challengable assumptions reflecting, in short, what Whitehead (1925) has referred to as the "fallacy of misplaced concreteness," long prominent in the history of human error.

We need only consider Darwin's (1872) cat-mouse-bee-clover chain in the "balance of nature," which has been cited for the greater part of a century with scarcely a question as to whether events actually work out as supposed. The eating of mice by cats, the destruction of bee nests by mice, and the fertilization of clover flowers through visits of bees were established as facts by Darwin's time—facts that modern observers could be expected to verify over and over again. But this would not prove, for example, that "the number of mice is largely dependent, as every one knows, on the number of cats." Nor are the grounds for doubt simply a question whether mouse mortality from cats is perhaps light in proportion to the overall abundance of mice or of whether mouse fecundity is great enough to outstrip predatory checks.

Of singular importance as misplacers of concreteness are intercompensatory or automatically adjusting trends in rates of loss and gain of many populations of vertebrates. Much of the loss just doesn't seem to count as a population depressant, whether severe or otherwise, whether through one agency or another. A balancing is indeed implied, but not one conforming to conventional versions of the "balance of nature." The Darwinian view of the interrelationships of organisms does not seem to lay undue stress upon the complexity thereof; rather, the apparent confusion is between complexity and sensitivity, between predation as a limiting factor and the symptoms of unbalance that are manifested by mortality from predation.

As an understanding of the workings of predation may hardly be gained without minimal insight into population phenomena of the prey, this paper will be far more concerned with analyses of the latter than with expositions of killing techniques and food habits of predators.

Of the quantitative data bearing upon predation pressures in vertebrate populations, only, as a rule, those small proportions resulting from investigations continued year after year on the same areas are likely to repay close study. The validity of a particular set of data must, in addition, be appraised according to the variables introduced by size of area and mobility of resident species, emergency crises, and other factors of sorts which, if not taken into account, may distort analyses. Often, too, an author's data may fit into a vastly broader scheme than his conclusions indicate or may even support the opposite of his deductions. While I have, from necessity, depended extensively upon my own work with higher vertebrates for general guidance, this paper is an outgrowth not only of a survey of the biological literature that seems to be the most informative but also of years of correspondence and discussion with contemporary investigators.

In view of the hopelessness of crediting individuals, briefly and at the same time adequately, with their contributions in a study having the

scope and background of this one (for partial résumés, see Errington, 1943: 804–806; 1945: 3), acknowledgements will be largely restricted to pertinent places in text and bibliography. Nevertheless, W. L. McAtee, H. L. Stoddard, and Aldo Leopold should be singled out for thanks for helping me quite in excess of what happened to have been their official responsibilities, particularly early in my professional experience.

Experimental manipulation of vertebrate populations has been tremendously handicapped by technical and economic obstacles, and many readers will probably be disappointed in how little the literature shows in this respect. The resulting deficiencies are substantial, but equivalents of excellent experiments have been furnished by some of the more comprehensive field or statistical researches. This is not solely a contention of field biologists, for as eminent a laboratory experimenter as Pearl so expressed himself in one of his last papers (1937).

In the treatment of vertebrate animals of prey to follow, the grouping is primarily intended for convenience. Many pages are devoted to mouse-like rodents and to gallinaceous birds, because they have been most thoroughly studied and furnish the best groundwork for making sense out of the multiplicity of puzzle-parts furnished by the others.

PREDATION AND RODENT POPULATIONS

In some ways, it might be more fitting to take up the literature on mice first in this section, but that on certain other rodents gives better perspective on the "key" phenomena associated with density effects and emergencies—without a consideration of which no accurate appraisal of the influence of predation is possible.

The Muskrat

The muskrat (*Ondatra zibethicus*) has been studied from the standpoint of predation and population to a large extent by myself in the north-central United States; and all statements concerning the species in this review and not otherwise documented are based upon the chief publication summarizing that work (Errington, 1943).

It became routine procedure to try to obtain, year after year, censuses of muskrats breeding on specific observational areas totalling many square miles; to record mortality and movements in as much detail as circumstances permitted; and to calculate net rates of increase (or loss) by early winter and reconstruct the reproductive fortunes of the areas' populations, using extensive specimen data on age and sex ratios and placental scars. Investigative methods were now and then checked by marking animals of known ages (an average of about 100 a year), by repeated handling and note-taking on nearly all litters born on given marshes during the breeding months, and by collecting (or obtaining the carcasses from fur trappers) of essentially entire population groups for examination. The effects of droughts and similar drastic emergencies, as well as those of epizootics, were measured according to opportunity. Data were gathered regularly on food habits and the responsiveness of predators to the availability of the muskrats as prey; and possible correlations were sought between differences in the kinds and numbers of predatory and "buffer" species and the relative degrees of security or vulnerability displayed by the muskrats.

The muskrat is subject to predation by many vertebrates, including its own kind and modern man. As an exotic in Europe, where its interspecific and subhuman enemies are largely species with which it has had less than a half century of racial experience, it has drawn much the same types of predation as in its native North America (Ulbrich, 1930).

The mink (*Mustela vison*), valuable fur-bearer itself, has received special condemnation from the fur industry for its depredations upon muskrats, and, in truth, by usual standards for judging predation, the mink is the outstanding "natural" enemy of muskrats. Under conditions favoring easy predation, a mink may live for weeks or months at a stretch on a virtually straight diet of muskrat, and its killing, too, may greatly exceed its needs for subsistence. It is perfectly true that the annual toll of muskrats by minks on a continental scale may run into millions of victims—potentially, we may be told, millions of dollars. Or, someone else may remind us of the services minks perform about city reservoirs, levees, dams, and other places where the muskrats may be pests.

This logic is unshakeable as long as its postulates are granted, but we have again the old matter of misplaced concreteness. Plenty of errors of fact can and do result from observers overestimating or underestimating the losses of muskrats through minks; these errors, however, are likely to be minor ones compared with those introduced by an appraisal of the population effect on the

basis of the numbers or proportions of prey animals killed.

Let us consider, according to seasonal categories, mink predation upon the muskrats of the north-central United States.

Muskrats dispersing from wintering quarters into an unfamiliar spring countryside suffered mortality from intraspecific strife, motor traffic, farm dogs, and many locally active native predators. The majority of the participants in this movement succeeded in establishing themselves in new home ranges with sufficient promptness to escape excessive losses, but variable numbers of individuals continued foot-loose and hazardous wandering as spring and summer advanced. Such habitual transients were commonly males, although, when the environment suitable for muskrats became crowded, females of all mature ages, unbred or pregnant, would be included. A harassed and battered lot congregating about the fringes of areas dominated by muskrats already in residence, the transients were a biological surplus, largely doomed through one medium or another.

At times, the minks subsisted on these unfortunates as long as any remained available, leaving practically none alive by early summer. At other times, minks or other predators capable of killing muskrats were absent from the places frequented by the vulnerable transients or, if present, for some reason did not respond to the vulnerability. In the event of predator pressure being inconsequential, the greater part of the balancing sooner or later took the form of lethal friction among the muskrats themselves.

Once established for the warm weather months in regular home ranges at tolerable density levels, adult muskrats lived with noticeable security from subhuman predators unless, of course, rendered vulnerable by drought, human interference, or other emergencies. The young, on the other hand, were at times subject to terrific losses from predation, not only during emergencies, as expected, but also because of intraspecific tensions.

Except at densities so low that mating was inefficient,—an important manifestation of the underpopulations notably studied by Allee (1931, 1938)—the annual increases of local muskrat populations from spring to fall, when plotted on coordinate paper against breeding densities, tended to define reverse sigmoid curves rather characteristic of given habitats (Errington, 1945: 27–28). This conformation to pattern was independent of some wide variations in rates of loss through different agencies, including that of predation.

For all the severity of observed predation on young muskrats, juvenile mortality was often traceable mostly not to predators, but to drowning, disease, parental carelessness, or—on occasion very dramatically—to intraspecific attacks. Losses from non-predacious agencies were especially apt to rise as predation losses declined, and vice versa, with intraspecific strife becoming dominantly operative when predation and the usual run of miscellaneous losses all happened to be low.

The spurious logic of reckoning population effects of predation upon young muskrats merely in terms of losses charged to one predator or another should by now be apparent. All one needs to do is to consider the automatic adjustments between rates of loss from different agencies and the evidence that the totality of those losses were fundamentally predetermined by adult densities in relation to habitats. The data permit going still farther. Within bounds reflected by an area's recovery curve, heavy losses of young early in a breeding season were apt to be offset later by the birth of extra litters as well as by lightened rates of loss. Conversely, successful rearing of early-born young often meant the doom of the late-born, and adults also responded to crowding by terminating their breeding long before their fellows in less congested areas.

With perhaps but minor oversimplification, it may be said that, up to midsummer, the death of a young north-central muskrat improved another's chances for living and that the numbers of young "normally" accommodated in a well-populated habitat depended upon the numbers that older muskrats collectively would tolerate.

Between the end of the main breeding season in late summer and the hard frosts of autumn, muskrats lived under non-emergency conditions with relative freedom from intraspecific strife, though considerable foot-loose drifting and readjustment of home ranges typically occurred. This peaceful state was accompanied by low rates of loss from predation, even when it was both preceded and followed by periods of acute friction and heavy losses.

In late fall and early winter, ordinarily frictionless and comfortably situated muskrat populations lived quite securely despite the presence of variable (sometimes extremely heavy) populations of

carnivores and raptorial birds. Naturally, the drought-exposed muskrats enjoyed no such security, nor did individuals escaping maimed from steel traps to wander over land and ice, the restless, the socially unassimilated strangers, and the handicapped, in general.

From mid-winter to spring, as sexual awakening progressed, evidence of increasing tensions became apparent in muskrat populations long before overland movements or frank fighting occurred on a conspicuous scale. Minks in particular were at this time able to prey upon previously secure wintering muskrats. Late winter predation of this sort showed much intercompensation in closely studied instances, slackening by March if heavy in February, even though both minks and muskrats remained in high densities. A plausible explanation would be that the predation upon muskrats decreased with the elimination of certain vulnerable individuals. At any rate, after suffering predation in late winter, substantial muskrat populations were observed to be noticeably free from predation and intraspecific strife during the spring dispersal. And when large populations wintered with exceptional freedom from loss, they seemed to suffer the more during the dispersal, if not through the attacks of minks, then through some other agency.

The seasonal picture permitted by the data on muskrat populations and predation shows thresholds of security as largely a matter of adult densities tolerated during the breeding months. The inverse relationships between numbers of adults resident in spring and numbers of young reared by fall seem pretty much linked with the months of greatest intraspecific intolerance, inasmuch as late summer and early fall were "normally" periods of diminished strife and associated losses. With the advent of late winter and spring, accelerated frictions and losses culminated in the new breeding season's threshold phenomena—the secure levels and the vulnerable surpluses—and the new season's reproductive trends according to the slopes of curves.

We may then see in the thresholds and inverse ratios a function of what can be defendably identified (Nice, 1941; Errington, 1943: 823, footnote 18) with the territoriality common to many vertebrates.

The numbers of breeding pairs, or equivalents thereof, tolerated in a specific habitat tended to be similar from year to year, irrespective of the less drastic environmental changes—moderate fluctuations in water and food when no actual emergency existed, for example—but threshold values could change.

Burrowing and lodge-building activities of the muskrats themselves were noted to raise for succeeding generations the habitability of sparsely populated tracts. Lay (1945) reported the opposite extreme in southern coastal areas: "Sometimes marsh destruction has resulted due to 'eat-outs' of 5 to 100 acres where peak populations were not sufficiently trapped." In Iowa, deterioration of marshes followed high water levels, with progressive aggravation of tensions among the muskrats (Errington, 1944). Concerning a different aspect of a series of wet seasons the same report states: "During late years, we have had the apparent anomaly of temendously increased numbers of breeding muskrats, over the state as a whole, having high rates of increase. No modification of principle seems to be thus involved, the differences clearly being due to expansion of habitable environment in consequence of heavy rainfall filling up previously dry farm ponds, marshlands and ditches. Rates of increase on the more permanent types of habitat have tended to remain in inverse ratio to breeding densities much as before, even at times of state-wide population ascendancies."

We should keep in mind that automatic adjustments may still operate significantly, even when obscured by a changed status of muskrat populations. The productivity of muskrats along central Iowa streams was influenced by the accessibility of corn (*Zea Mays*) Errington, 1941a); not only were stretches well supplied with this favored food occupied by about twice as many breeding females but, for similar densities of females, the spring to fall increases were also about twice as great in food-rich, as in food-poor, environments. Nevertheless, the data from those streams followed their apparent area curves so closely during non-emergency years (Errington, 1945: 27) that the differences associated with food seemed to bring about local reorientations without sensibly affecting either the breeding levels or the collective productivity of an area's muskrats. Increased numbers of adults or young along part of a drainage system chiefly meant fewer in another part.

Certain distinctions as to the workings of intercompensations should be explained. In 26 of 37 local situations in which droughts were observed

to affect muskrats lethally on Iowa areas, drastic predation had scant influence on the population status of the muskrats, as virtual annihilation of the latter doubtless would have taken place in the absence of predators. In four instances, drought crises were sufficiently brief so that the absence of predators probably would have improved the chances of survival of more of the muskrats that were preyed upon while exposed. The most non-compensatory type of predation occurred through the selective and specialized hunting tactics of a family group of northern plains red foxes (*Vulpes regalis*), which almost totally eliminated the exposed young weeks ahead of any ordinary schedule of drought mortality. Many of the victims actually caught by the foxes surely would have fallen prey to minks or otherwise have been lost during two drought exposures in summer and fall, but the net reduction charged to the fox activities was the equivalent of a nearly straight diet of muskrats over a two-month period. (In addition to Errington, 1943: 850, 858–859, 881–882, see Errington and Scott, 1945.)

Then, too, while intercompensatory trends may be said to have existed in late summer and early fall losses, to the extent that the victims were insecure enough to make immaterial what agency or combination of agencies did the reducing, severe losses at this time of year could have distinctly non-compensatory aspects. As late as this, in the north-central breeding and rearing seaons, all or most of the adults had passed into sexual quiescence, and most of the "normal adjustment" mortality already had taken place. Heavy late losses thus had the effect of being superimposed upon the earlier, rather than serving as substitutes or as reproductive stimuli in a system of natural counterbalancing. But late predation by subhuman enemies, aside from that drawn by handicapped muskrats, was typically so benign that man remained very nearly the sole vertebrate in the region capable of exerting directly the pressure necessary to force muskrat populations below levels of intraspecific toleration.

The reader may by now see numerous ways in which neglect or incorrect apprisal of conditioning factors may introduce great error into analyses of predation upon muskrat populations. Next, we shall take up one of the trickiest causes of misled reasoning—depression phases.

The literature grouped under the subject of periodic or cyclic fluctuations of vertebrates is extensive but scattered (for reviews, see Huntington, 1931; Mac Lulich, 1937; Clements and Shelford, 1939: 177–199; Elton, 1942). It is largely outdated and conjectural, and almost every conceivable explanation has been advanced by recent authors, especially in terms of predation, parasitism, epizootics, malnutrition, weather cycles, and sun spots. I cannot see that any of the resulting hypotheses meet the demands made upon them, though perhaps this may be due mainly to human shortcomings in segregation and interpretation.

So far as the muskrat is concerned, Elton and Nicholson (1942) concluded that a strongly marked, approximately 10-year cycle in numbers of this species was shown by Canadian fur returns and that this cycle ran parallel with but preceded in phase a similar cycle in the snowshoe hare (*Lepus americanus*) and other vertebrates long known for their periodic fluctuations. The parallelism was regarded as affording evidence of climatic control of the different population rhythms.

These authors are certainly correct in ascribing many declines of muskrats to dry years, and, to the extent that droughts occur in cycles, it may be agreed that muskrats fluctuate likewise. But how much may the gross fluctuations of any animal as sensitive to emergencies as the muskrat truly be linked with the fluctuations of as hardy a wilderness form as the snowshoe hare? How much may gross fluctuations only obscure the common denominators actually operative?

For southwestern Ontario, Figs. 16–20 of Elton and Nicholson show decreased muskrat abundance for the winters of 1934–35 and 1935–36, a trend toward stability by 1936–37, and an accelerating recovery by 1937–38 and 1938–39. The Iowa muskrats some hundreds of miles to the south, if considered solely on the basis of numbers, might also be judged to have reached a low point in a cycle in 1934–35 and to have been in an ascendancy by 1938–39; but the population was rather high in 1935–36 and distinctly lower in 1937–38 than in 1936–37 (Errington, 1943: 893).

However, it may be doubted that the depressed levels of either Iowa or Ontario muskrats in 1934 significantly reflected the "10-year game cycle." After the dissociation of variables due to patent emergencies such as droughts, rates of summer gain for Iowa muskrats, 1933–43, appeared to follow the usual inverse ratios with the singularly interesting exceptions of 1936 and 1937 (Errington, 1945: 27–28). In the latter years, depressed rates

in relation to density occurred quite independently of droughts.

And in 1936 and 1937, the low of the cycle on Minnesota study areas became apparent for the snowshoe hare (Green and Evans, 1940a,b) and the ruffed grouse (*Bonasa umbellus*) (King, 1937). These "classically cyclic" species showed at this time unusually low rates of gain or unusually high rates of loss in relation to densities, and similar phenomena were noted for other mammals and birds of the north-central United States (Errington, 1945). Examining the available data with the above criteria rather than gross fluctuations in mind, we may see evidence of a profoundly depressive influence acting with a certain synchrony and periodicity upon many of the region's vertebrates, including the muskrats.

Whatever that influence was and whatever were the mechanics of its workings, it seemed to be something apart from climate or environment as these are commonly defined. Among other things, it was attended by increased vulnerability, with respect to given densities, of a wide range of vertebrate prey.

Murine Rats

Turning to the literature on what, from man's standpoint, may be the most important rodents in the world, *Rattus* spp., we find much reference to the stated efficiency of various animals as ratters, and the usual assumptions are made as to population effect of the predation observed.

Even after making allowance for differences in size, murine rats appear to have greater intraspecific tolerance than do muskrats. Fall or winter populations of the latter seldom exceed 20 per acre over sizeable areas in the northern United States, and a winter catch averaging 74 per acre from 128 acres of Louisiana marshland (Arthur, 1931: 314) is the nearest counterpart I have found of the more than 4,000 barn rats (*R. norvegicus*) poisoned on three acres about a set of Iowa farm buildings during a month's campaign (Gunderson, 1944). Yet, low to moderate populations of barn rats plainly are not always frictionless, and attacks upon young by old have been frequently observed.

So far as the limited data show, intercompensatory trends exist in the loss and recovery rates of *Rattus* spp. Accelerated breeding as an accompaniment of underpopulation was indicated by Zetek (1917): "The influence of plague in the rat association [of India] is in the nature of a radical disturbance of equilibrium . . . after a large percentage of the rats had succumbed to plague, there came a vigorous breeding spell. This . . . is but a natural effort to re-establish again a relative equilibrium."

In the laboratory, female albino rats that were not allowed to suckle their young "produced many more young during their life than did the other groups, and particularly in the early part of their reproductive life" (Asdell, Bogart, and Sperling, 1941). Although females having their young destroyed at birth had more opportunities to conceive than did the others, they also "were in better condition and therefore had more litters which were more regularly conceived . . . . It has been repeatedly shown that lactation is a more severe tax on the animal than is gestation" (Babcock, Bogart, Sperling, and Asdell, 1940).

Barn rats may live, spring to fall, at considerable distances from buildings in the north-central United States, but the species is not hardy and requires food-rich, sheltered habitats in the colder parts of the region. In southern Wisconsin, the status of rats attempting to winter in corn shocks left in fields was insecure, and they were subject to heavy if not annihilative predation, notably but not necessarily from the great horned owl, *Bubo virginianus* (Errington, Hamerstrom, and Hamerstrom, 1940). In southern Iowa fields, the rats were observed to winter somewhat more successfully, though they still seemed exceedingly vulnerable where habitats were at all deficient. The insecurity of the rats under such conditions has points of analogy with the insecurity of drought-exposed or otherwise unfavorably situated muskrats.

It could be that the presence of snakes, small mustelids, or similarly redoubtable rat killers able to pass through small openings may lower the habitability for rats even of excellent living quarters. Crabb (1941), after conducting an intensive study of the prairie spotted skunk (*Spilogale interrupta*) on southeastern Iowa farms, reported that "predation on rats in winter about farm buildings was very noticeable. It was observed at several places on the area that a heavy population of rats during the summer and fall completely disappeared, or nearly so, during the winter months when a spotted skunk was in residence. Whether the skunks killed more than they drove away is a question, but, nevertheless, they appeared to exercise a controlling influence on the rats."

The propensity of rats, when frightened, to abandon premises has features appraisable with difficulty. If abandonment means only local, comparatively frictionless adjustment, we have no more ground for imputing depressive effect to a disturbing agency than in the case of non-lethal adjustments of muskrats in response to penetration of their lodges by minks (Errington, 1943: 871, 875). If abandonment means eviction, footloose wandering in strange and inhospitable places, and accentuation of intraspecific tensions elsewhere, net consequences to the rats may of course be greater.

In contrast with Crabb's tabulations of rat remains in over nine per cent and in over six per cent of the skunk droppings gathered in winter and spring, respectively, no rat remains were listed in the summer droppings, and this author stated: "Several observations were made of spotted skunks living apparently amicably side by side with Norway rats during this period . . . under the same buildings and wood piles." Although he associated differences in skunks killing and utilizing rats with the availability of other foods, the evidence need not all be so construed.

There are enough eye-witness accounts of small-bodied predators killing rats away from holes to provoke questions as to what extent killing occurs in the innermost retreats or may be centered upon vulnerable "overflow." At least a large proportion of the victims of raptorial birds and of carnivores unable to penetrate deeply into the retreats should consist of the more poorly situated, transient, restless, harassed, or surplus individuals. Gunderson stated that on ordinary Iowa farms considerable numbers of rats are visible both day and night if the population is over 1,000. Rat remains were found in nearly twice as many (9.0 per cent : 5.2 per cent) of the pellets of north-central horned owls in the warmer, as in the colder, months; and the highest predation rates were in areas where geography and prey associations might lead one to expect the greatest numbers of field-living rats (Errington, Hamerstrom, and Hamerstrom, 1940: 774, 787–788, 832–847).

The opposing seasonal trends in the representation of rats in skunk and owl diets could be a manifestation of automatic balancing. Without implying that favored parts of rat populations live with absolute security from subhuman predators, one may easily note that substantial populations are accommodated in some of the main "strategic" quarters, diligent hunting by flesheaters and severe losses about outskirts notwithstanding. In a climate more suitable for rats the year round than that of the north-central United States, variations in predator pressure might mean the difference between many tracts of marginal environment being habitable or untenable. Yet basic dissimilarities may not be great: Doty's (1938) description of field habitats of *R. norvegicus* on tropical Kauai compares with those of temperate North America in summer, as relates to the safest retreats, trails to choice feeding grounds, and the types of places having sparse or no rat populations.

"Mice"

Of the animals known as mice, members of the Cricetidae and Muridae have been most studied, not only because of the economic loss they may occasion when abundant but also because of interest in them as subjects for biological investigation. Of these mice, the genus *Microtus* has contributed as much as any to what knowledge we have of populations.

When abundant, mice—sometimes rising to densities of thousands per acre—may be spectacularly preyed upon; and, at densities much lower than peak levels, may continue to serve as staple foods for large elements of predatory faunas. A view widely held among modern investigators, including Tinbergen (1933), has been that predation tends to have more controlling influence when mouse densities are low.

Russian publications on rodent populations have not been widely accessible, but Elton (1942: 87–90) has summarized much of this work, devoting considerable space to the findings of Kalabukhov, who "developed . . . the following ingenious theory about population dynamics.

"He [Kalabukhov, 1935] points out that as a population of voles or mice or ground squirrels increases, the food supply of the occupied areas will tend to diminish. When food is scarcer the animals move about over larger distances. This greater movement exposes them to more of their enemies and so mortality through these predators will be greater . . . .So, if these processes were operating, an unusually good food supply would, through its influence on movements, reduce mortality and encourage mass-increase towards outbreak scale. When high density had again reduced the food supply, the wider range of movement would automatically tend to remove a larger number of

animals through predation . . . Kalabukhov does not seem to have considered the fact that the food supply of many mouse-like rodents, and especially voles, *is* their cover, and that eating down the available food, besides causing increased movements, may often automatically expose the animals to their enemies. This further concept reinforces his own theory . . . Kalabukhov's theory rests also upon the important assumption that destruction of mouse-like rodents by predators takes place on a significant scale. . .

". . . what we need to know in addition, however, is whether the actual number of rodents destroyed is sufficiently large to affect the control of numbers. To settle this we require figures for the density of predators, the amounts of rodents that each species eats in a certain time (and in different seasons), and the densities of the various rodents concerned . . . Kalabukhov and Raevskii . . . [1933] during their Caucasus house-mouse investigation, removed rings [i.e., bands used in marking individuals] from the pellets of predatory birds, and calculated that about 1.5 per cent of the mice were eaten by these birds every day. This is apparently the only investigation so far in Russia which fulfils a good many of the criteria we need. It suggests an enormous destruction of mice by birds.

"Klimov . . . [1931] describes a heavy destruction of voles (*Stenocranius gregalis*) and hamsters (*Cricetulus songarus*) by hawks and owls on a field in Siberia . . . He states that an initial population of 58 rodents per acre was reduced to about 9 per acre in a month—a destruction of 85 per cent.

"We shall not, perhaps, attach too much importance to the actual findings of these and other field experiments, which are still too limited to allow any generalizations to be made. But they show that in many parts of Russia and Siberia predators are still an important factor to be studied and that they have locally, and perhaps over wide areas, an effect that is not negligible, and may be important. It is possible that they are indeed a master factor in rodent oscillations, as Kalabukhov believes.

". . . Kalabukhov's idea . . . is one of the special Soviet contributions toward the theory of the subject. Also, it has been put forward in Soviet literature in such a way as rather to displace the theory that epidemic diseases dominate the dynamics of rodent populations. It is, in fact, the application of epidemiological ideas, usually thought of in connection with host-parasite interrelations, to the interaction of preys with their predators—a group of concepts that has already been canvassed in the theoretical speculations of Lotka and Volterra, and more recently, of Nicholson and Gause."

In these and other samples of the mouse literature, the reader may see the product of a great amount of data-gathering and thought, but he will discover little evidence of authors' considering possible roles of intercompensatory trends in loss and recovery rates.

Statements as to effects of predation upon the mice are thereby left decidedly open to question, especially in view of the apparent parallels to be seen in basic population phenomena of mice and muskrats, and the extreme severity of the predation that muskrats have been observed to bear with little or no *net* depression of population levels.

I am not sure how much the almost annihilative predation upon communities of *Microtus* spp. by the least weasel (*Mustela rixosa*) reported by Criddle (1926) in Manitoba may compare with predation by minks invading the habitations of north-central muskrats, but some of the predation suffered by the muskrats would look, in the absence of information on conditioning factors and intercompensations, fully as influential as the weasel predation upon the mice. Habitat changes and emergencies obviously have their roles in the severe predation upon mice discussed by Kalabukhov and by Naumov (1937b). A. Murie's (1936) listing of microtines as animals that his Michigan foxes were able to hunt with a certainty of success reflected not only the abundance and vulnerability of the mice but also a selectively and intelligently directed hunting effort not likely to be exhibited by many species of subhuman predators.

The finding of mouse remains (principally of *Microtus pennsylvanicus*) in 56 per cent of 200 scats of the short-tailed shrew (*Blarina brevicauda*) by Eadie (1944) in New York occurred at ". . . the end of a period of increase in the local microtine cycle in the winter of 1942–43. Thus the high percentage of field mice in the shrew diet coincided, in part, with a period when the mice were presumably experiencing a high degree of mortality generally [a decline from 80 to 12 mice per acre was indicated by trap-removal quadrat censuses]. . . It is possible, then, that the shrews

may have been feeding on mice weakened or dead from disease. On the other hand, when the mouse population was high, simple availability may have led the shrews [Eadie's figure of three shrews per acre could hardly represent more than a moderate density] to prey heavily upon them."

Turning again to the work of Kalabukhov and Raevskii in the Caucasus, we may read, this time as quoted by Gause (1934: 24):

"The picture of the destruction of mice by different predators is a curious one. At the beginning of the destruction about the same number of rodents is devoured daily. But as the density of rodents diminishes it becomes more and more difficult to catch them, and the number of mice devoured gradually decreases. Finally a time comes when the relations between the density of the rodents, the presence of cover or refuge (burrows, vegetation, etc.) and the biological peculiarities of the predators becomes such that the latter can devour the rodents only in rare cases. In this way the number of the rodents remains constant." Elton's (1942: 77–78) comparison of "stations of permanent survival" in locusts with Naumov's (1936, 1937a) findings on segregation in microhabitats of different species of rodents suggests still more the operation of thresholds of security in mouse populations, as does another of Naumov's (1937b) papers referring to existence in "optimum habitats only" at "the beginning of the reproduction season."

Overflows of mice are widely recorded, and these are of about all imaginable types, from local reorientations to mass-migrations. When high densities are involved, animals may appear literally everywhere (Hall, 1927; Heape, 1931), and their individual vulnerability to predation doesn't look very different from that of wandering and ill-situated muskrats. Whelan's (1939) specimens of *Microtus pennsylvanicus* taken during an abundance peak reveal sex ratios and behavior trends similar to those of muskrats under like conditions; and, from the work of Blair (1940a), like comparisons could be made of breeding-season behavior of this mouse and of the muskrat.

The experiments of Ginsberg and Allee (1942) showed that individual experience strongly conditioned the fighting prowess of laboratory mice, and Retzlaff (1938), experimenting with albinos, reported an influence of density on death and reproductive rates, in good measure because of behavior patterns of the animals; these are social traits that seem to be suggested by what field evidence exists on muskrat fighting. Bailey (1924) found that captive *M. pennsylvanicus* were very ready to fight strangers and intruders and mentioned that "Occasionally, a male is trapped in the meadows with his skin cut full of holes from a fight." From Ranson's (1934) paper on *M. agrestis* as a laboratory animal, it may be judged that this species generally fights under about the same conditions as *M. pennsylvanicus*.

Again I quote Elton (1942: 204–205), with reference chiefly to the laboratory studies of *M. agrestis* by Ranson and others: "Another factor in mortality is the temperament of the vole, which is not adapted to the complete occupation of all habitable grounds, with heavy pressure of contact from neighbors. . . This social antagonism among voles probably exists in nature, and may be very important at different levels of population, and may prove to explain some of the mortality at higher numbers."

Although Leslie and Ranson (1940) commented on the lack of knowledge of social habits of *M. agrestis* in the wild, and Elton's treatise does not inform us whether the mortality of young through attacks of older voles increases as an accompaniment of rising densities to anywhere nearly the degree found in Iowa muskrats, Elton told me in conversation in 1938 that he considered the latter very possibly to be the case. If this is what happens, the British work becomes of still greater interest:

". . . The voles that start each breeding season in the spring are adult ones that have over-wintered for at least five months without breeding. . . It seems certain . . . that the population that starts the breeding cycle each spring does not survive until the following spring, but is replaced by its own grown-up offspring" (Elton, 1942: 180). Farther on (p. 203): "Given this comparatively short life . . . and an intermittent breeding season, any vole population in Great Britain runs near the edge of biological safety in the spring of the year: for the continuation of it depends on the success of the over-wintering population in propagating itself before dying from ecological causes or simply from 'wear and tear'. If mortality from any cause becomes greater in the spring months, these survivors may die before bringing their families through pregnancy and weaning stages, to provide a succeeding generation. Alternatively, any unusual mortality among the young voles of the year

will have a similar effect." Leslie and Ranson (1940) regarded the months of March to May or June as the "crucial section of the yearly cycle" for the voles and discussed birth and death rates in this connection: "The general impression left on one's mind is that of a species, which at times will of necessity fluctuate violently in numbers, owing to even comparatively small disturbances of the breeding cycle."

Concepts of such sensitivity in population equilibria may be partly discounted on grounds of undetected intercompensations, but, if intraspecific strife in voles ever approached the intensity recorded for muskrats during overpopulations when "losses of young from attacks of older animals . . . were sufficient practically to nullify continued reproductive effort" (Errington 1943: 824), pronounced reduction of the breeding stock of voles naturally could follow their peak years. A gross decline resulting therefrom would have its own bearings upon predation rates, but not in the sense of that kind of periodic cycle manifested by depressed gains and heightened losses in relation to density. In the Cascade Mountains of Washington, Howell (1923) found jumping mice (*Zapus* sp.) "fairly swarming in July, 1920," at the height of the breeding season, and "only about five per cent . . . showed external signs of immaturity"; about Puget Sound, where the animals were "common though not abundant . . . the young . . .considerably outnumbered the adults."

Few data have been published from which numerical changes in wild mouse populations may be followed over periods of three years or longer. Outstanding is Hamilton's (1937) study of local populations of *M. pennsylvanicus* in New York over the four-year cycle, 1933–36. As later plotted in one of my papers (Errington, 1945: 26), the rates of gain of Hamilton's mice during the upgrade of the above cycle showed inverse trends in relation to spring densities in 1933 and 1934, and then a rate higher in 1935 than in 1934. There was a net loss during the breeding season of 1936.

Hamilton explained the acceleration of breeding in 1935 partly in terms of increased chances of a female in oestrous meeting a fertile male at times of higher densities, as well as in terms of increased numbers of young per litter and prolongation of the breeding season. He tabulated data on percentages of nursing mice that were also gravid, as an index to the rate of breeding; the averages for the main breeding months, April through August, turn out to be 55.1 per cent for 1934, 63.6 per cent for 1935, and 59.3 per cent for 1936. No early season data are given for 1933, but year-to-year comparisons may be made of the averages for September and October: 37.8 per cent for 1933, 33.3 per cent for 1934, 56.1 per cent for 1935, and 61.4 per cent for 1936. Since the accelerated breeding was pretty well sustained in 1936, not only at high density levels but also after a drastic population decline, the role of increasing densities in the acceleration would seem unproved. And we must consider that 1934, with a heavier population, showed a lower rate of net increase than 1933, besides a lower breeding rate for the only period for which data are comparable.

The increase in average size of litters born during the main breeding months of 1935 was marked; but comparison with data on percentages of old (over 45 grams in weight) mice among adults, given in another of Hamilton's papers (1941a), would seem to reflect stage of maturity more than population density. Bailey (1924) observed that the first litter in the species usually had four young, but that when the females were fully gown, six or eight young at a birth were usually produced, and a similar trend is shown by the records of Leslie and Ranson (1940) for *M. agrestis*.

The breeding season of Hamilton's mice was remarkably prolonged during the high population year of 1935. Instead of ceasing in November, as in the preceding three years, breeding continued at a reduced rate through the winter of 1935–36. It may also be judged that breeding reached its peak unusually early in the spring of 1936. However, despite Hamilton's (1937) statement, "Following a period of reduced mouse populations in the spring and summer of 1936, it became evident that a smaller share than usual of the surviving mice were breeding," comparison of percentages of breeding females for 1935 and 1936 (see Hamilton, 1941a) with the population curves for those years does not bring out the correlations one might have expected after the 1936 decline. The percentages of breeding females in the middle of September and the middle of October were indeed higher during the low-density autumn of 1936 than during corresponding periods of 1935, and we may question whether the mere presence of high mouse densities really did induce the breeding in the winter of 1935–36. A possibility coming to my mind is that the reproductive success in 1935 might have been poor enough for many adults

to have induced prolonged breeding. Samples of adults taken from June to September of that year consisted of well over 30 per cent of large animals (exceeding 45 grams), whereas only in July, 1936, was a comparable percentage reported (Hamilton, 1941a).

As long as we consider a cycle in terms of gross populations, we may agree with Hamilton's (1940a) view "that cycles in adjacent parts of one state, or in adjacent states, do not necessarily coincide." He added that the 1932–36 cycle in meadow mice did coincide throughout all of the northeastern United States. Moreover, the termination of the northeastern mouse cycle coincided with substandard (in relation to densities) rates of increase for numerous higher vertebrates, including those characteristically showing the so-called 10-year cycle, in New York and the north-central region, alike (Errington, 1945). The distinction should therefore be mentioned that what Hamilton studied in detail may not have been simply one of the commoner three- or four-year mouse fluctuations.

The idea of a basic 10-year cycle in muriform rodents of Russia has been emphasized by Vinogradov (1934). In Elton's (1942: 82) words: "Sviridenko stresses the irregularity of occurrence, and the great differences between contiguous regions. Vinogradov, while clearly recognizing this irregularity, brings out the strong ten-yearly trend which keeps showing itself, like a long swell through a sea of shorter, choppy waves."

Dr. A. Ogloblin translated for me from Vinogradov's original paper, and there is no synchrony that I can see between the 10-year peaks of the Russian rodents and other vertebrate cycles of which I know; but this does not rule out the likelihood of at least regional synchronies between depressed phases of mouse and other animal cycles. Data published by Elton, Ford, Baker, and Gardner (1931) on populations of the long-tailed field mouse (*Apodemus sylvaticus*) near Oxford, England, reflect typical-looking inverse ratios for 1926 and 1928, with rates of increase being considerably depressed in relation to density in 1927. Whether through coincidence or conformity to a master pattern, the low of the general "game cycle" in the north-central United States was also reached about this time. The 1927 breeding season of the British field mice was distinctly prolonged, a phenomenon which would seem to link up with the severe mortality from some undetermined pathological cause reported for the spring.

Burt (1940) regarded predation as the principal medium of reduction of *Peromyscus leucopus* in Michigan. Apart from general questions as to population effect that remain unanswered, there is the variable resulting from the population curve presented for these mice (see his p. 40) having been based upon data gathered from June, 1936, through June, 1937—coinciding at least in part with the low of the "game cycle" for the region!

On the whole, the evidence points to so many basic similarities in the population phenomena of muskrats and mice that we may hardly regard the losses suffered by mice through predation as any more proof of population effect than the losses through predation that are often such a spectacular symptom of vulnerability in muskrats. Still, as with muskrats, we must not assume that the counterbalancing naturally occurring in mice has to be complete. Possibly Elton (1942: 20), despite his neglect of intercompensations, has expressed the current status of our knowledge: "It would not be right to decide now that enemies and parasites exert no control over the numbers of voles. But it certainly seems less likely than it did ten years ago that they are a dominant influence."

Miscellaneous Rodents and Lagomorphs

For the sake of perspective, one might ask to what extent the density phenomena and intercompensations described for mouse-like rodents apply to other rodents and their allies.

Although a certain amount of fighting may take place among lagomorphs, the common North American rabbits and hares may at times demonstrate extreme tolerance of crowding. They are staple foods for many vertebrate predators, so much so that in the northern wilderness their numerical status may greatly influence that of some of their enemies (Mac Lulich, 1937; Elton, 1942). But they are by no means free from automatic mechanisms.

The cottontail, *Sylvilagus floridanus*, evidently may winter with considerable security at levels differing according to locality. Hendrickson (1943) reported spring survivals of about one per five acres on a central Iowa area for six consecutive years, 1937–42. On a Wisconsin area, the threshold appeared to be low in proportion to the early early winter, 1929–30, population of rabbits (Er-

rington, Hamerstrom, and Hamerstrom, 1940: 786–787), as in the case of Kalabukhov and Raevskii's mice. Haugen (1943), in Michigan, noted variable spring survivals on particular quadrats, but the survivals on the quadrats collectively were very similar for the two years, 1938–39, for which data were presented, and the fall populations were not greatly in excess of those of spring. During what may be termed "normal" years, 1938–41, Scott (1943: 463–464) found that predation of central Iowa red foxes was much less in proportion to numbers of cottontails in summer and fall than in winter and spring. Of another lagomorph, the collared pika (*Ochotona collaris*), Dixon (1938: 194) wrote that the "population in Mount McKinley National Park is remarkably stable ... approximately the same number of individuals are to be found in certain given rock slides year after year."

In northern Minnesota, Green and Evans (1940a) obtained census figures of between 493 and 539 snowshoe hares for the springs of 1933–35 on their most intensively studied tract of 1.2 square miles—which looks like threshold security during a favorable cyclic phase—then spring figures of 313, 167, 55, and 92, from 1936 to 1939, as the low of the cycle was reached and passed. Cottontail remains were found in about the same proportion of horned owl pellets of a southern Wisconsin area for the low-cycle winter of 1936–37 as for winters of much greater rabbit abundance (Errington, Hamerstrom, and Hamerstrom, 1940: 786). Observations of Criddle (1938) in Manitoba and of Sheldon (1930) in Alaska suggest increased vulnerability of snowshoe hares in relation to numbers during cyclic lows. The Minnesota hares showed a high incidence of "shock disease" or hypoglycemia during 1936, a time when they "were in sharp decline" (Green and Larson, 1938).

Summer gains of Haugen's cottontails tended to be in inverse ratio to spring densities, whether artificially stocked animals were included or excluded (Errington, 1945: 26); and Hendrickson continued to note rather uniform rates of gain—in the vicinity of 200 per cent—from rather uniform spring densities, 1937–42. Southern's (1940) reference to the wild rabbit (*Oryctolagus cuniculus*) in England,—"It is noticeable that in spite of the large number of young born during the season the total population of the warren never rose above 162" —would seem to reflect usual trends toward automatic adjustments and inverse ratios. For the snowshoe hare, I could find no data on "normal" rates of increase in relation to density. At the low of the cycle in 1937, the survival rate of young on Green and Evan's (1940b) area was the lowest observed. Mac Lulich (1937: 49) recorded a very sharp summer decline at Buckshot Lake, Ontario, at the beginning of a depression in 1932, which was followed by almost complete disappearance of the hares by 1935, the last year represented

Habitat differences may obviously have a bearing on the predation suffered by cottontails (A. Murie, 1936) and the population densities maintained (Haugen, 1943), but it is not clear how much the variability in predator pressure may determine the size of populations able to live in marginal environments. The virtually annihilative fox predation upon Ohio cottontails reported by Williams (1936) appeared related to ecological upsets; nevertheless, it occurred through the medium of a species capable of exerting selective and intense pressure. Murie observed in his work in Michigan that "foxes seem to delight in rabbit hunting," probably preferring this prey to most others, and that, under the existing conditions of abundance, were seemingly able to hunt deliberately "with a certainty of success." The rabbits continued to flourish, however. Furthermore, we must remember that again and again lagomorphs recovering from depressed levels show rapid population gains from one year to the next, the attentions of wild flesheaters not withstanding.

The matter is not merely one of lagomorphs being prolific or of making their gains when enemies are either numerically or proportionally scarce, as there are just too many instances of lagomorph populations apparently conforming to patterns, even despite pronounced differences in numbers of such able hunters as horned owls and foxes.

Returning to the rodents, we might easily list as staple foods for predators (at least seasonally) many species of common sciurids. A. Murie (1944: 229), after a careful investigation of predator-prey relations in Mount McKinley National Park, wrote: "It is likely that predators take the equivalent of the yearly increase among the ground squirrels [*Citellus parryii ablusus*], thus leaving an ample breeding population ..." Evans and Holdenried's (1943) data on Beechey ground squirrels (*C. beecheyi*) in California and those of Burt (1940) on the chipmunk, *Tamias striatus*, in

Michigan show, so far as they go, inverse ratios in summer gains (Errington, 1945: 25–26).

Allen's (1943: 113–116) findings on Michigan fox squirrels (*Sciurus niger rufiventer*) suggest compensatory breeding in response to severe losses, etc., and other counterbalancing tending toward inverse ratios in rates of gain. "Small breeding stocks have been consistently more productive, proportionally, than large ones. The evidence is convincing that in creating large game yields attention to range conditions is the important thing, and that a drastic fall reduction of the population will, in itself, help to create those conditions necessary for maximum breeding and survival of young."

The severity of owl predation upon flying squirrels (*Glaucomys* spp.) may look excessive in proportion to their visible numbers (Errington, Hamerstrom, and Hamerstrom, 1940: 791), but this is in part due to under-estimation of the numbers actually attained by those nocturnal, little tree-dwellers (Seton, 1929, 4: 369–372, 383). Predation upon prairie dogs (*Cynomys* spp.) by black-footed ferrets (*Mustela nigripes*) may in many respects be likened to that upon muskrats by minks, and its population effects probably have been similarly misappraised. At any rate, whether or not ferret predation is really instrumental in annihilating or driving away entire colonies (Seton, 1929, 2: 568–572), there can be no doubt that ferrets may kill immense numbers of prairie dogs.

Predation upon marmots (*Marmota* spp.) does not seem to differ in essentials from that upon the smaller sciurids, and in the same category might be placed predation upon wood rats (*Neotoma* spp.) (Vestal, 1938; Vorhies and Taylor, 1940), pocket gophers (Geomyidae) (Bird, 1930; Criddle, 1930), and beavers (*Castor canadensis*) (Seton, 1929, 4: 491, 493). All are subject at times to severe local predation, perhaps by predators having special attributes (such as snakes and mustelids for entering burrows and the canine flesheaters that are so quick to turn situations to their own advantage), but here, too, we see the recurring role of basic population phenomena. The victims described are so often the immature, the ill-situated, the restless, the wanderers, the surpluses, or the otherwise handicapped—conspicuously those finding themselves too far from suitable refuge at the time of attack by an enemy. Among beavers, for example, Bradt (1938) found forced emigration of two-year-old individuals to be of regular occurrence, and Soper (1937) referred to occupancy of habitats that were clearly marginal. Cyclic depressions, as well as density relations, have an imperfectly ascertained influence; over an expanse of land extending roughly from Oklahoma to New England, tree squirrels generally reached low levels in 1936 or 1937 (Allen, 1942; Blair, 1938; Chapman, 1938; Hamilton, 1939), contemporaneously with the cyclic low of many mammals and birds.

In considering the more specialized types of predation having greater apparent population effect we should think not only of exploits of opportunistic canids, etc., but also of the specialities of some of the prey. Indeed, it may be argued that the slow-breeding, dull, clumsy, but peculiarly gifted porcupines (*Erethizon* spp.) may suffer enough predation over much of their range (Taylor, 1935; O. J. Murie, 1935; A. Murie, 1940, 1944; Sperry, 1941), even in country lacking their famous enemy, the fisher (*Martes pennanti*) (Seton, 1929, 2: 476–479), to appear as potentially controllable through natural predation as any of their order.

PREDATION AND POPULATIONS OF NON-GLIRIFORM MAMMALS

Ungulates

Predation upon ungulates has aroused man's antipathy since the beginnings of pastoral cultures, if not long before in relation to common food species. Domestic livestock, especially modern strains bred for food production, may be killed by almost any efficient predator of suitable size having access to them. Those early range cattle of the southwestern United States, the longhorns, were, however, adept at taking care of themselves, and they thrived in wild country despite the presence of formidable predators—indeed, Dobie (1941: 167) considered that these representatives of *Bos taurus* could defend themselves more successfully against wolves than could some of the native big game. The reindeer (*Rangifer tarandus*), as an imperfectly domesticated species introduced into Alaska from Siberia, appears to be distinctly less successful, when not protected by man, than the native caribou (*R. arcticus*) in maintaining itself against wolves (Young and Goldman, 1944: 254–258), although the caribou constitutes staple wolf food over much of Arctic and Subarctic North America (Clarke, 1940: 107–109; A. Murie, 1944: 52–54). Of the common farm ungulates, sheep (*Ovis aries*) seem about as inherently vulnerable to the attacks of predators as any to be brought to mind, yet the native North American mountain sheep, *O. dalli*

and *O. canadensis*, show age-tried adjustments against the eagles, wolves, and other native flesh-eaters (A. Murie, 1944: 95–143).

The low uniform densities of the roe deer (*Capreolus capreolus*) in Scotland (Darling, 1937: 92) suggest threshold phenomena, as does the same sort of evidence for North American mountain sheep. In the latter species, a great deal of the predation is suffered by handicapped and surplus animals; but there is evidence, too, that predation, as by wolves, can have a controlling influence or may restrict populations to superior habitats (A. Murie, 1944). A certain degree of self-regulation of numbers unquestionably occurs even among the more gregarious of ungulates. The viciousness of combat between males of hoofed animals has long been noted, and Darling (1937: 35) in his study of the red deer (*Cervus elaphus*) observed that "... overcrowding results in anti-social behavior which in itself is one type of check to the further increase of a cramped population."

Nevertheless, we may see in many species of hoofed mammals a propensity to increase up to the limit of the food supply and to the extent of actually starving, thus conforming to the Malthusian thesis more literally than do the general run of higher vertebrates (McAtee, 1936). Except for man's livestock overgrazing poorly managed pastures throughout history, the North American Cervidae have furnished the outstanding examples of ungulates eating themselves out of their habitats. In the United States, the species most prominently concerned have been mule deer (*Odocoileus hemonus*) and white-tailed deer (*O. virginianus*) (Rasmussen, 1941; Leopold, 1943), but, when excessively abundant, moose (*Alces americana*) and elk (*Cervus canadensis*) have likewise demonstrated their potentialities for ruinous overuse of their food resources (A. Murie, 1934; 1940; O. J. Murie, 1944). Moreover, many other ungulates may denude local areas of edible or accessible vegetation; and species of large animals that congregate naturally in immense herds must necessarily have a certain mobility.

The larger-sized wild ungulates suffer from subhuman predation chiefly when immature, aged, crippled, starved, sick, or isolated from their fellows. In many instances, utilization by predators is almost exclusively a matter of scavenging upon carcasses of animals dead from non-predacious causes—see especially Clarke's (1940: 104–105) account of the associations of carrion-eating animals frequenting caribou crossings over a rapid-filled river. "Normal" adults of elk, moose, bison (*Bison bison*), and musk-ox (*Ovibos moschatus*) are not only physically very formidable, but the latter two have also evolved effective group tactics for defence against such enemies as wolves (Seton, 1929, 3).

The literature gives instances of the more efficient large predators killing wild ungulates seemingly at will, but it doesn't follow that this holds generally true. Deer have long been recognized as staple food of the cougar (*Felis concolor*), which Hamilton (1941b) reported to "have been especially destructive to cattle since the deer eradication campaign was instigated in lower Florida in an effort to control the fever tick." Averages of two or three deer killed per adult cougar per week on the Kaibab Plateau reflect the notorious overabundance of deer at that place (Rasmussen, 1941: 247), whereas Hibben (1937) found evidence that cougars hunting in other areas in the southwestern United States had by no means an easy time killing the deer upon which they subsisted. He examined 11 cougar victims, each of which exhibited "some characteristic to which death of the animal might be attributed"—malproportions, injuries, and pathological states.

We may also see parallel connections between the abundance of game and the ease of predation by wolves. Surely no one need be surprised at wolves killing deer on a conspicuous scale, where wolves are present at all, in the midst of the top-heavy deer populations of some parts of northern Minnesota, Wisconsin, and Michigan; nor should it seem strange that, where the hunting is poorer, even such able predators may have to take what they can get. Clarke (1940), although estimating the wolf kill to be half of the annual increase of caribou on the Canadian barrens, believed that the wolves tended to be somewhat underfed. In Mount McKinley National Park, Alaska, where caribou constitute the main food of wolves, A. Murie's (1944) detailed observations suggest frequent unsuccessful hunts, with most predation being borne by stragglers and calves.

In referring to the northern bison (*Bison b. athabascae*) in Wood Buffalo Park, northwestern Canada, Soper (1941: 402–403) wrote that wolves "are not as yet anything like as destructive as they apparently were to herds on the Great Plains . . ." and that the data "would seem to indicate that the ratio of loss from this source is very

low in relation to the bison aggregate." While abundant, these northern bison were below primitive numbers and were obviously well-situated in their habitats; there was "also an abundance of game for . . . [the wolves] to prey upon—easier game than buffaloes." Soper concluded: "If the whole matter could be adequately checked, it would probably be found that most examples killed are subadults ailing in some way, or individuals in the last stages of senility . . . The mature in vigorous health are not likely to be attacked successfully and such animals may also be capable of protecting their calves."

The young of the larger ungulates and both adults and young of intermediate sizes may suffer much from relatively minor predators when circumstances favor predation, notably in the absence of the wolves, cougars, etc., that would be expected to be the chief killers in a fauna undisturbed by man. Darling (1937: 44) reported fox predation upon fauna of Scottish red deer that would be astonishingly severe if suffered by smaller species of deer in the western or north-central United States. Possibly Marston's (1942) records of bobcat (*Lynx rufus*) predation upon white-tail adults in Maine would be no less astonishing if relating to deer living in areas having more formidable predators (compare with Rollings' (1945) study in Minnesota). Both cases, which are extreme in that predators killed large numbers of animals beyond their ordinary size limits for prey, could exemplify intercompensatory trends not differing more than in degree from those observed for muskrats.

Intercompensations in rates of gain and loss are evidently less complete in the life equations of the ungulates, however, than in the muskrats. There is vastly more reason that I can see for believing that predation can have a truly significant influence on population levels of at least some wild ungulates. A rather famous case of antelopes (*Antilocapra americana*) increasing in Oregon after the reduction of the abundant coyotes, which preyed upon the young, looks circumstantially convincing (Riter, 1941). The coyote depredations also may have been conditioned by the handicaps of underpopulation to which the antelope were subject before the "rapid increment during the . . . years when the nuclear herds had become large enough to hasten multiplication" (Einarsen, 1939). A. Murie (1944: 180–181) concluded that, while the caribou of Mount McKinley National Park "seem to be adjusted to withstand the losses" from wolves, wolf predation "is apparently an important check on their numbers"; also that the mountain sheep and the wolves there may be in equilibrium, with losses among the yearlings through wolf predation being "probably most important in holding the sheep numbers in check" (see his p. 143). Without losing sight of the fact that much more than predation or lack thereof may be involved in the great changes recorded for American deer populations of recent decades (Storer, 1932; Leopold, 1943), we may detect pretty strong indications of the depressive influence of predation upon the numbers of the deer (Horn, 1941; Rasmussen, 1941; Leopold, 1943).

Most examples of predation upon wild ungulates showing a reasonably clear evidence of population effect have one thing in common: the predators involved had special abilities as killers—indeed were usually *Canis* spp., members of a subhuman group inferior as mammals only to man in adaptiveness and potential destructiveness to conspicuous, relatively slow-breeding forms. Such canids may not only show a high degree of selectivity in their preying but may also indulge in sport, practice, or "storage" killing on a considerable scale when they have opportunities to do so (Young and Goldman, 1944). Like man, they may to some extent be diverted from a particular prey species by the availability of another more preferred (A. Murie, 1940, 1944)—a matter of special population significance in that predation losses inflicted by canids seem less marked by intercompensations than losses from general predation. Against canids as against man, ungulate prey may often find a good measure of security in first-class habitats even when poorer grades are untenable. Clarke (1940: 84) wrote of a species much reduced through human exploitation ". . . the places where the musk-oxen have survived down to the present on the mainlands are those where they were most numerous 100 years ago."

Primates

Primate biology is so obscured by sociological complexities as well as by factual deficiencies that I, for one, feel unsure about how far underlying trends may be traced. Heape (1931: 64–67), after presenting T. A. Barns' conclusions (summarized in a letter dated August, 1926) on territoriality in *Gorilla* spp. in Africa, saw that "Not only are tribal rights over a wide territory observed but family

rights over camping grounds . . . The difference between the latter and the rights claimed by a nomadic Arab over the tent which harbours his family is but a very short step . . . Mr. Barns, in his letter . . . adds a few words about chimpanzees [*Pan* sp.], to the effect that very much the same laws regarding territory hold good for them . . ." Territoriality in central American howling monkeys (*Alouatta palliata*) (Carpenter, 1934: 47–50) doesn't seem basically different from much behavior of primitive peoples as reviewed by Carr-Saunders (1922: 202–211). Later, Carpenter (1940: 152–164, 178–184, 197–198) described territoriality and its manifestations in gibbons (*Hylobates lar*) in Siam and generalized: "It would seem that the possession and defense of territory which is found so widely in the vertebrates, including the sub-human and human primates, may be a fundamental biological need. Certain it is that this possession of territory motivates much primate behavior."

Entirely apart from contraception, infanticide, and other of what may be called artificial measures to limit human increase, there is a great deal of natural counterbalancing in birth rates and mortality (Pearl, 1925; Hogben, 1931).

Perhaps as simple an extreme as any is furnished by the Polar Eskimos of Greenland, whose "number, determined by the years of minimum food supply, has probably never been much greater or much smaller than now" (Ekblaw, 1921). The censuses of natives attached to Moravian Missions in Labrador have shown little change in the last century (Elton, 1942: 310). In contrast, mankind's tremendous increase over the hospitable parts of the earth since the seventeenth century has been linked with "new discoveries and new ideas that made it possible for man to exploit far more effectively than he had known how to before the natural resources for human living inherent in the earth on which he lived" (Pearl, 1937). But Pearl (1925: 20) made plain that "even when social evolution does manage to put a kink in the curve of population growth, it has not done it by altering any biological law. It merely shifts, by a greater or smaller amount, the absolute base from which the law operates. Then the process goes on as before." Pearl's words, incidentally, have their applicability to curves of population growth that may be conceived of, or actually constructed, for Iowa muskrats during periods of their own "expansion of . . . effective universe" "in consequence of heavy rainfall filling up previously dry farm ponds, marshlands and ditches" (Errington, 1944).

One may visualize from Carpenter's (1934: 33) account of the land activities of arboreal monkeys how predation could increase with increased population tensions in a sparsely wooded environment or during times of movement between clumps of trees; and the excess, or "complemental," males would not appear to be the securest of animals. There is no reason to suppose that early man did not suffer typical sorts of predation. In modern times, the exploits of a fair variety of "man-eating" predators have repeatedly emphasized the helplessness of children and unarmed, or poorly armed, adults when seized by the larger flesheaters. During the past few hundreds of years, man has on occasion served as scarcely less than staple prey for wolves in certain European localities (Matheson, 1943).

Carnivores and Insectivores

With reference to predatory mammals, themselves, the adage, "One tiger to a hill," would seem to bespeak observation of self-limiting trends in populations of large carnivores. In varying degrees, this also may pertain to lesser carnivores, though often intolerance may be manifested not by strict defence of territorial boundaries but rather by something of a rotating drift of solitary-living individuals, with lethal friction or intraspecific predation increasing with frequency of encounters.

The latter seems pronounced in *Mustela* spp. Soper's (1919) trapping figures indicate winter densities of about 10 short-tailed weasels (*M. cicognani*) per square mile in western Alberta at a time when the species was very common; and in good Iowa and South Dakota habitats ". . . maximum early winter mink densities . . . seemed to level off at about 15 per square mile" (Errington, 1943: 892). All of these mustelids suffer from general predation in the north-central United States far more than one might expect from their relatively low numerical densities (Errington, 1937; Errington, Hamerstrom, and Hamerstrom, 1940); but field studies have also shown ". . . nearly as many minks killed by other minks as by the rest of their non-human enemies combined" and a possible connection between densities, toleration limits, and denning facilities (Errington, 1943: 815–816).

Similar to Iowa mink densities were those determined by Crabb (1943) for spotted skunks,

which are subject to predation as by canids and large raptors, notably horned owls. The larger members of the Mephitinae are also known to reach like levels of abundance, but they seem not to suffer so much direct attack from subhuman enemies, though they certainly are not avoided entirely. Some intraspecific fighting—including that having "territorial" functions—may be regarded as normal behavior among skunks, but some, too, has pathological aspects, as Allen and Shapton (1942) found in a low-density population of *Mephitis m. nigra* in Michigan, 1940.

Steuwer (1943), working on raccoons (*Procyon lotor*) of a Michigan area, 1938–40, found juvenile survival to be high and most of the annual loss to be due to human hunting. His data (see his pp. 234–236), nevertheless, show an inverse relationship between density of adults (including variable proportions of non-breeding yearlings) and rates of increase in the population samples that were live-trapped and marked.

A. Murie (1944: 15) judged that intraspecific intolerance in the wolf, *Canis lupus pambasileus*, "may hold a population in check . . . at an optimum level which would be rather high." He gave elsewhere in the same writing (pp. 43–44) an example of intolerance toward a stranger on the part of animals showing much tolerance within a group—behavior often seen among dogs (*C. familiaris*) and doubtless occurring generally among the canids. This same author also wrote in 1939 (1940: 20) that the Yellowstone "coyote population has not greatly changed during the last 4 years," or since discontinuation of artificial control. Maximum winter densities of gray foxes (*Urocyon cinereoargenteus*) averaging about five per square mile were reported from central Wisconsin, and a similar figure might also apply to red foxes (Errington, 1945: 6–7). The 1940 home ranges of two neighboring family groups of *Vulpes regalis* covering about 2,000 acres of Iowa "hill country," as depicted by Scott (1943: 441–446), are suggestive of self-limiting mechanics, especially when compared with the more centrally located, single home range of 1939.

Foxes—the young in particular—are subject to attacks by a considerable variety of subhuman enemies, not the least of which are their canine relatives. Gray and red foxes may very possibly be mutually depressive in southern Wisconsin (Errington, 1945: 7). Scott and Selko (1939) logically attributed the underpopulation of certain denning habitats of *V. regalis* in central Iowa to "repressive effect of dogs hunting over the areas." In the prairie regions of North America, red foxes seem to have decreased with increase of coyotes (Seton, 1929, 1: 505–506); this may chiefly reflect ecological changes, but displacement of foxes by coyotes is not beyond reason. The possibility has been considered that the coyote, in greatly extending its range northward, might displace predators native to the Mount McKinley National Park (Dixon, 1938: 164–165). During later work in that park, A. Murie (1944: 221) obtained few data on this point; he did conclude, however, that the population of *V. kenaiensis* "has not been harmed by the . . . [native true] wolves . . . and that both species can subsist in the same region in good numbers." Grinnell, Dixon, and Linsdale (1937: 417) found that California desert areas having numerous kit foxes (*V. macrotis*) also had "relatively large numbers" of coyotes.

The primitive order, Insectivora, includes species which, if not strictly territorial, are unsociable enough to bring about some degree of self-limitation. The predacious ferocity of short-tailed shrews remarked by numerous authors is not excusively an interspecific matter and would surely work against concentrations whereby individual adults came in frequent contact with each other. Their densities usually being low (Blair, 1940b) compared with those of mice, it is understandable why many investigators have found them scantily represented in predator diets. Short-tailed shrews may nevertheless constitute locally important prey (Errington, 1932; Errington, Hamerstrom, and Hamerstrom, 1940), as also may other common insectivores (Guérin, 1932; Davis, 1938; Hibbart-Ware, 1940; Hamilton, 1940b; Scott, 1943). The latter author reviewed the evidence of foxes showing distaste for insectivores, sometimes eating, sometimes discarding, their kills, but fox predation on his own study area in Iowa followed the relative abundance of moles (*Scalopus aquaticus*) and the shrews, *Cryptotis parva* and *Blarina brevicauda*. Although his foxes lived in a food-poor environment for north-central agricultural states and hence may have fed with atypical economy, the regional picture of predation upon insectivores could remain one much in proportion to population, notwithstanding whether or not the less particular feeders, such as owls or insectivores, themselves

take up the population slack when the carnivores have more leeway in their dietary choices.

PREDATION AND POPULATIONS OF WILD GALLIFORMES

The Galliformes include some of the most popular game birds, and, in so far as man has long endeavored to increase or maintain their numbers for his own purposes, he has not overlooked the more conspicuous depredations of natural enemies upon them. Repression of "vermin" (i.e., predators) has been standard procedure, if not cherished dogma, for generations of game keepers and sportsmen, notably in the Old World.

Investigations of life histories and populations of gallinaceous game birds have been restricted neither to North America nor to the past twenty-five years (Committee of Inquiry on Grouse Disease, 1911), but Stoddard's (1931) pioneering work on the bobwhite quail (*Colinus virginianus*) in the southeastern United States, 1924–29, had unique importance in establishing techniques for, and giving impetus to, long-term programs of local, intensive field research.

The Bobwhite Quail

Stoddard advocated a moderate and selective repression of predators known to prey heavily upon bobwhites (birds or eggs) in conjunction with other management measures on shooting preserves in his region. His views (for a recent expression, see Stoddard and Komarek, 1941) are the product of a great amount of observation, experimentation, banding, and laboratory work, and he has been in an exceptional position to correlate shooting yields from vast acreages with different types and intensities of management. In one respect, however, the published data from the southeastern quail preserves are seriously deficient: Largely because of technical obstacles to making accurate censuses of bobwhites under conditions prevailing there, a reviewer is given no basis for comparing net rates of gain or loss in relation to density for areas kept under year-to-year observation.

The findings from a fifteen-year Wisconsin study (Errington, 1945) may be summarized as reflecting population phenomena of the species over much of the north-central United States. Though far narrower in scope than Stoddard's, this investigation had the distinct advantage of having been carried on with the aid of tracking snows, which often permitted exact and repeated counting of locally resident bobwhites between October and April.

Percentages of gain, spring to fall, for bobwhite populations on the Wisconsin and other areas of the region, when plotted against spring densities, tended strongly to define reverse sigmoid curves, the slopes of which varied with specific areas. Most variations in temperature, rainfall, farming practices, and kinds and numbers of predators and "buffers" had no detected influence on the net rate of gain shown by a bobwhite population for a breeding season.

Two factors clearly did have influence.

Introduced ring-necked pheasants (*Phasianus colchicus torquatus*) and Hungarian partridges (*Perdix perdix*) depressed the bobwhite gains in so far as mixed populations of pheasants and bobwhites (or of all three species) gained collectively in inverse ratio to spring densities, much as could have been expected for equivalent densities of bobwhites alone. In other words, pheasants and partridges co-occupying given tracts of land with the bobwhites might be regarded as living at the expense of the bobwhites whenever the latter were subject to density-depression. The lethal aspects of such competition were not due simply to one species eating the other's food, destroying the other's eggs or young, or driving out the other by aggressive action; interspecific antagonisms noted were of benign types and of very irregular occurrence, and the mere presence of the exotic Galliformes seemed to be enough to depress bobwhite gains. Native grouse had scant perceptible effect on population behavior of the bobwhites, possibly because of more complete segregation of the two in their respective environmental niches.

The most pronounced of all of the depressions of summer gains in relation to density took place through the evident operation of what have been called phases. The published rates of gain of bobwhites and pheasants, collectively, on the principal Wisconsin area for 13 of the 14 summers, 1930–43, fell into or very near two curves fitted by F. A. Brandner, who used the form of equation:

$$y - y_o = \frac{K}{1 + Ae^{bN}},$$

where y = per cent of gain or loss, N = density, e = the base of natural logarithms, and K, A, and b are parameters estimated in the process

of fitting. Of these curves, one having the formula,

$$y - 15 = \frac{265}{1 + 0.15e^{0.0206N}},$$

reflected materially lower gains in relation to density for the summers of 1930, 1938, 1940–41, and 1943 than did the other,

$$y - 20 = \frac{251}{1 + 0.049e^{0.0187N}},$$

for the summers of 1931–35, 1937, 1939, and 1942. The phases represented by the curves shifted back and forth without recognized periodicity or more than limited synchrony with phase shifts on other north-central areas. Nor did the shifts seem to be correlated with changes in the predatory fauna, however much the changes in phase affected the vulnerability of populations to predation.

A third phase, characterized for one thing by extreme depressions of rates of gain in relation to density, was operative in 1936, and sometimes in 1937, on all north-central areas for which we have population data on bobwhites. This was synchronized with depressed gains of other higher vertebrates over the region and seemed to be chiefly a manifestation of the low of the long-observed yet still unsolved "10-year game cycle."

Because of the bobwhite's sensitivity to the hunger and weather crises that occur to some extent almost every winter in the northern parts of its geographic range, losses from emergencies at this season had to be reasonably well dissociated and appraised before any basic patterns could be traced. When this was done, rates of non-emergency winter loss (including those from simple predation and from interspecific and intraspecific adjustments of the bobwhites, themselves) proved to be much according to patterns set by densities and phases. For mixed bobwhites and pheasants on the principal study area (4,500 acres) during the "normal" phase of the 1929-44 series of winters, the non-emergency losses were low and showed practically no acceleration with rising densities, as long as populations remained below a 300- to 330-bird threshold of security. Then, as populations exceeded the threshold, the non-emergency—especially predation—rates of loss went up sharply, this part of the curve conforming fairly well to the sigmoid:

$$y - 5 = \frac{31}{1 + e^{19.67-.0486N}}.$$

Non-emergency loss rates in relation to density for the depressed phase, defined by another sigmoid,

$$y = \frac{54}{1 + 19.11e^{-0.0179N}},$$

for the winters of 1938–39, 1940–42, and 1943–44 (also 1929–30, which had originally been assigned to the "normal" phase), indicated decidedly lowered thresholds of security; vulnerability to predation of even moderately low populations was pronounced for the known duration of the phase. Data points for two winters—1939–40 and 1942–43—fell above the curve for the first and most favorable phase and were regarded as being transitional between the two phases.

Of the series of winters covered, 1936–37 was the only one not identified with the above two phases. It was marked by an unusually high rate of non-emergency (also of emergency) loss and coincided with the low of the region's "10-year game cycle."

The most clearly demonstrated phase linkages were continued, broken, or reestablished without detected reference to season. As long as the favorable phase persisted, rates of summer gain were high in relation to spring densities, and non-emergency winter losses were severe only at or over "saturation" densities for the specific area; whereas the rates of summer gain and non-emergency loss of the main depressed phase, while following seemingly rigid, density-determined patterns, nevertheless reflected what hardly could be other than a shifted level of influence. This, to judge from the Wisconsin curves, commonly meant that a spring population could be about half again as high during the favorable, as during the depressed, phase and yet give a similarly high rate of increase; that more than twice as many birds could winter during the favorable, as during the depressed, phase without suffering any higher rate of non-emergency loss.

It may be seen from the north-central data that populations absorbed the impacts of many conventionally regarded "limiting factors" with a resilience fully equal to that of the muskrats previously discussed in this paper. As in the muskrats, breeding season densities of adults have certain aspects of biological base levels, of which the thresholds of security and the inverse ratios in summer gains both look like functions. The exact nature of the changes occurring with the phase shifts remains unrevealed by anything known to me, but I have been unable to conceive of a factor

so operating except in large part through the psychology of the bobwhites, themselves. Simple predation upon the bobwhites may in turn be thought of as a function of density of the latter, though such predation comes much nearer to being in direct proportion to density in the main depressed phase than in the favorable phase, and is still nearer at the "10-year cyclic low."

The nearest to a geographical intermediate between the north-central population data and Stoddard's findings on southeastern bobwhites is provided by Baumgartner's (1944a, b) work in Oklahoma, 1939–43. This study covered an emergency winter, 1939–40, comparable to northern ones in deadliness; but the evidences of thresholds of security, of inverse ratios in rates of summer gain, and of intercompensations following shooting and artificial stocking go much farther in illustrating an essential similarity in north-central and south-central population mechanics.

In the southeast, Stoddard (1931: 226, 341) undoubtedly anticipated some of the things brought out by north-central and south-central figures. "If less be killed than the annual increase the species will build up to the supporting capacity of the ground. Beyond this point an additional limitation in the form of disease, parasitic infection, or reduced ability of reproduction increasingly operates to reduce the number, unless overflow to adjoining areas takes place." And "every area of quail ground has its own 'saturation point' as to population." It is plain, however, from his treatment of biological balance and management that he neither regarded winter predation as being confined largely to birds exceeding thresholds nor summer recoveries as tending to be in inverse ratio to spring densities, with relative independence of vertebrate depredations.

A possible explanation, other than lack of comparable data, for differences in the appraisal of predation as a population factor in the north-central and the southeastern regions has been that predator-bobwhite-"buffer" relationships may be less resilient in the southeastern states (Errington and Stoddard, 1938; Errington, Hamerstrom, and Hamerstrom, 1940). The intensity of predation suffered by southeastern bobwhites at times when cotton rats (*Sigmodon hispidus*)—the principal rodent prey of many of the region's predators—become scarce after peaks of abundance had no detected counterparts in the north-central study areas. Furthermore, the more formidable predators upon bobwhites in the southeast were less numerous, even when observed to be destructive, than they "normally" were in Wisconsin and Iowa. On the other hand, a greater variety of staple prey seemed to be available for the north-central predators, so that declines of some staples seldom forced the predators into the stringent hunting that would be required to reduce ordinarily secure bobwhite populations.

Another variable lies in the higher bobwhite densities reached in the southeast. Autumn averages of a bird per acre over large tracts of the best Georgia preserves are so much in contrast with northern populations, usually not exceeding a bird per four acres—and often somewhere between a bird per 10 to 20 acres, if not lower—that a reviewer may wonder how much the heavier predator pressures upon the southeastern bobwhites might have been a response to density alone. Seemingly atypical predator pressures have been noted elsewhere, particularly in Europe, when wild Galliformes were maintained at comparably high densities.

The many intercompensations, special and extreme cases, regional differences, and involved relationships that may be made out in the literature on the bobwhite are enough to discourage generalizations. It is rather plain, at least on occasion, that predation may have some influence on population levels of this bird, and questions remain as to how much the poorer grades of environment might be habitable if predator pressure were greatly lessened. It is also plain that substantial variations in the composition and densities of local predatory faunas often occur without changing the population status of the bobwhites. In view of the extent to which bobwhite populations may be essentially self-limited and subject to emergency and phase depressions, the possible action of predation as a true depressant appears to be considerably less important than the numbers of the birds killed or consumed by predators could lead one to think.

The Ruffed Grouse

The ruffed grouse is a backwoods and wilderness bird that frequently suffers conspicuous predation. Like the bobwhite, its population phenomena show many intercompensations, but it has less renesting ability; and, although less susceptible than the bobwhite to winter emergencies, it has more marked periodic fluctuations.

In King's (1937) data from northern Minnesota there may be seen what appear to be manifestations of high thresholds of security during three winters when the grouse were at or near the peak of their cycle. October populations of between 525 and 995 birds on 1800 acres were reduced by April to quite uniform levels of between 443 and 455, 1931–34. A southern Wisconsin population in a marginal environment wintered with fair security at much lower levels over a longer period of years (Errington, 1945: 23). In New York, Edminster (1938) reported a pronounced insecurity for densities exceeding an average of a bird per four acres in the best habitat.

Published data on spring and fall densities on sizeable areas kept under observation for periods of four years or longer reveal underlying tendencies for rates of summer gain to follow inverse ratios much as in the bobwhite (King, 1937; Edminster, 1938; Fisher, 1939; Errington, Hamerstrom, and Hamerstrom, 1940: 814; Errington, 1945: 22–23). Comparing Minnesota and New York data for the upgrade and peak years of the cycle, we find that the percentages of nesting failures were very much higher in New York, those for Minnesota being almost incredibly low, averaging "slightly less than three per cent"; in contrast, the Minnesota losses of young were extremely high, "normally at least 75 per cent." In 1935, reduced productivity of grouse in New York was attributed to excessive rainfall, but, regardless of the adverse weather, the net rate of gain by fall turned out to be about what might have been predicted from the high spring density of that year. In another paper, Edminster (1939) wrote of artificial repression of predators on some of the New York experimental grounds being accompanied by lower nesting losses of the grouse than on check areas where predators were left undisturbed; but juvenile mortality remained about the same in the experiments and the checks, and strong trends toward counterbalancing were otherwise evident.

Depression phases for the ruffed grouse apparently progressed in a less irregular manner than for the bobwhite. Sometimes the changes had aspects of a gradual tightening over periods of two to four years, followed by similar periods of relaxation; at other times, the tightening and relaxing stages occurred in rather definite downward or upward steps, with rates of gain and loss responding for a couple of years first to one level of influence and then to another. By 1936 and 1937, the grouse of both the Minnesota and New York areas were at or near the low of the cycle, and their gains were lowest and their losses highest in relation to densities, as was also true for so many other vertebrates of the north-central states. Clarke's (1936: 21, 23) graphs of abundance in Ontario have no dates later than 1934, but the species over most of that Province had not then reached the actual low of the cycle (Fallis, 1945); Clarke noted that "even though the first year of dying-off in an area has reduced numbers to a point where the birds may be regarded as scarce, the succeeding year may show a similar reduction of summer flocks."

During seasons known to represent the low of the cycle, loss rates of bobwhites and ruffed grouse, when plotted against densities, were much in direct proportion to density, summer and winter, old and young birds, alike (Errington, 1945: 31). Thus, the thesis of McAtee (1932) and others that predation tends to be in proportion to population seemed to be the most literally realized at such times for adults of these higher vertebrates—far more indeed than for the ordinarily more vulnerable immature during favorable phases. The fact that not all (sometimes not even most) of the mortality suffered at the low of the cycle took place through predation should not obscure the evidence of acutely heightened vulnerability and the essentially doomed status of great population groups, irrespective of the particular agencies to which the birds happened to fall victim.

The literature describes immensely variable mortality from weather, physiological deficiencies, infectious disease, parasitism, and predation, during cyclic lows of ruffed grouse and snowshoe hares, but the common denominator I see is that of species unthriftiness synchronized on a more or less regional scale. In some ways, the mortality is reminiscent of that suffered by muskrats and bobwhites at times of overwhelming crisis, when losses—including those from predation—may be pretty much in direct proportion to numbers of the animals affected. It is true that a drought emergency for muskrats or a starvation emergency for bobwhites may accomplish more depopulation in a shorter time than that to be expected during a cyclic decline extending over a period of years. Yet one could reasonably ask if the extreme depression phases might not impose the equivalent of emergency conditions, or, anyway, deprive certain higher vertebrates of the survival advantage they

ordinarily gain through intelligence and special adaptations, thereby leaving them temporarily in somewhat the category of those lower vertebrates and invertebrates that are killed or consumed largely as encountered by flesheaters in the course of random search.

Might this afford any part of an explanation for the sweeping destructiveness to ruffed grouse of goshawks (*Accipiter gentilis atricapillus*) reported by ornithologists. Forbush (1929: 119), for example, flatly stated: "A great flight of Goshawks into the United States in fall or winter is followed invariably by a scarcity of Ruffed Grouse." Numerous other authors have recounted instances of grouse coverts having been cleaned out by these hawks during their periodic "invasions" from the northern wilderness, which rather characteristically accompany the cyclic lows of the grouse and hares.

The goshawk is a formidable predator, but I cannot see that it is incomparably more formidable than a big Cooper's hawk, or, for that matter, the well distributed great horned owl. The horned owl is not exempt from the general principles governing the availability of prey, and large expanses of wilderness are coinhabited by goshawks and ruffed grouse (and by horned owls, too), without the grouse suffering undue depredations in "normal" years. An "invasion" by goshawks may introduce its own unanswerable questions as to "buffer" relationships and the effects of a mass influx of predators, but, whether depressed phases were accompanied by many, few, or no goshawks, ruffed grouse have still followed cyclic patterns.

Interspecific competition might be a factor obscuring behavior of the ruffed grouse on lands marginal to it and frequented by other Galliformes. The figures available for southern Wisconsin (Errington, 1945: 13–14, 23), while depicting no depressive influence of ruffed grouse on bobwhites, do hint of bobwhites damping the increase of grouse. From 1941 to 1943, the ruffed grouse there experienced a patently favorable phase coinciding not only with a region-wide ascendancy of their own kind but also with low to moderate densities of the area's bobwhites. The grouse were seen in many unusual places, including typical if underpopulated bobwhite habitats, and they wintered in unusual numbers. The corresponding stage of the region's grouse cycle of a decade earlier was poorly defined on the area, and, throughout the period during which the favorable phase for grouse of that cycle could have been applicable, the coverts suitable for bobwhites remained consistently filled with the bobwhites, themselves.

The Ring-necked Pheasant

Being the most abundant (astonishingly so in places, as in eastern South Dakota) exotic game birds of northern United States, pheasants of course draw predation. Their basic population phenomena look at least in part similar to those observed for bobwhites and ruffed grouse. The pheasants did not always show the definiteness of response that the others did to density factors, phase depressions, etc., but some of this may be due to deficient census data. Nevertheless, pheasants obviously may be far more tolerant of crowding (expect possibly in the breeding months) and, in winter, may congregate by hundreds about areas of a few acres.

Limited evidence of thresholds of winter security is available from northwest Iowa (Errington, Hamerstrom, and Hamerstrom, 1940: 803–804). A moderate reduction in numbers of pheasants wintering in 1934–35 over the numbers wintering in 1933–34 was attended by markedly lower representation in horned owl diets; then, as restlessness of the pheasants increased with the onset of the breeding season, the incidence of pheasant remains in the owl pellets reflected predation that was judged to be very much more in proportion to actual pheasant abundance in the springs and summers of both 1934 and 1935. At low densities in the marginal pheasant environment of central Iowa, the pheasants likewise wintered with little loss, yet suffered rather severely from predation in the spring.

Like bobwhites in summer, north-central pheasants typically appeared to be satisfied with hatching one brood, and, until succeeding, made repeated efforts to renest following loss of egg clutches. Hamerstrom (1936) recorded failure of nearly 80 per cent of the nests kept under observation during a three-year study in northwest Iowa, yet between 70 and 80 per cent of the hens were calculated to have brought off their season's broods (Errington and Hamerstrom, 1937). Considerable intercompensation was also manifested by loss rates of the young. In one locality, depredations of marsh hawks (*Circus cyaneus hudsonius*) upon the young pheasants were substantial, but this did not seem to accelerate the

shrinkage in size of pheasant broods, as broods on neighboring lands not hunted over by the hawks and those living in northwest Iowa as a whole experienced practically the same average rates of decline.

As previously indicated, the rates of summer gain for bobwhites and pheasants, collectively, on north-central areas tended to be in inverse ratio to spring densities, much as could have been expected for bobwhites, alone. Although the above adherence to pattern was looked upon primarily as an attribute of the bobwhite parts of the mixed populations studied, the rates of gain for pheasants were as a rule comparatively high for low densities and low for high densities. If plotted against densities on coordinate paper, these rates for Einarsen's (1942) pheasants in Oregon and Bach's (1944) in North Dakota are extremely reminiscent of the density and phase effects suggested by north-central ruffed grouse (Errington, 1945: 22–23); parenthetically, I may add that this concept is being expanded by my colleague, Dr. Thomas S. Baskett, in a manuscript based upon unpublished Iowa data.

Einarsen's data suggest that the cyclic low of his west-coast pheasants may have come in 1937–38 rather than coinciding with the 1936–37 low of the north-central "game cycle." In Iowa's best range, the reproductive success of pheasants was so poor, 1936–37, that hunting seasons were closed (Bennett and Hendrickson, 1938); and summer gains in the central part of that state showed perhaps more that could be interpreted as cyclic influence than did southern Wisconsin gains (Errington, 1945: 18–19). Farther east in Ohio, Leedy and Hicks (1945: 81) recognized no "long-term fluctuations (or cycles) in the pheasant population," but they gave no evidence of considering modifications in density responses as criteria of cyclic behavior.

In attempting to appraise the population effect of predation upon pheasants, we find ourselves particularly confronted by the questions of how habitable a given range would be for a given species, were it not for predators; and to what extent marginability of range is a matter of predation. It was observed in sparsely occupied north-central pheasant habitats that these birds, low densities notwithstanding, were often highly vulnerable to predatory enemies. At times, it seemed that, if there were any pheasants around, something got them, whereas the northwest Iowa localities in which the severest depredations upon pheasants were observed were also known for excellence of pheasant shooting (Errington, Hamerstrom, and Hamerstrom, 1940: 823). Complicating still more our efforts to arrive at valid generalizations are the possible non-compensatory aspects of maiming or killing large numbers of incubating hens by mowing machines (Hamerstrom, 1936; Leedy and Hicks, 1945), and unusually eliminative predation, as by "specializing" foxes.

Miscellaneous Wild Galliformes

We have little to guide us in appraising the population effect of predation upon most species of gallinaceous birds save fragmentary data, but these fragments afford glimpses of what should be, by now, familiar types of intercompensation, density patterns in rates of loss and gain, threshold behavior, and depression phases.

In the southwestern United States, the social relationships of the California quail (*Lophortyx californica*) have been well enough studied (Emlen 1939; 1940; Howard and Emlen, 1942) to tempt a reviewer to fill by analogy some of the hiatuses still remaining in our knowledge of sociality in the bobwhite. So far as the data from the two species are comparable, many basic similarities are indicated. Rates of gain of California quail (Emlen, 1940) and of the scaled quail (*Callipepla squamata*), studied byJohnson (1943) in New Mexico, would seem to reflect inverse ratios subject to depression phases, the gains of the former being depressed about as severely in relation to density in 1937 and 1938 as were those for bobwhites during the low of the north-central "game cycle," 1936–37. Horn (1938) also referred to a poor hatch on the part of a decreased adult population of California quail on another area in 1937. In 1942, the scaled quail on Johnson's area experienced a pronounced decline and depressed gain in relation to density, "accompanied by an extraordinary reduction of cottontail rabbits"; if this represented a cyclic low, it was not synchronized with any recognized cycle in other regions.

Otherwise concerning automatic adjustments, Sumner (1935: 247) acknowledged the likelihood of a decreased toll by natural forces following the reduction of surplus California quail through shooting, and cited instances of the lack of effectiveness of artificial repression of predators as a management measure. Horn's (1938) account of this species responding to experimental reductions of

heavy populations of nest-destroying ground squirrels has convincing features, though I would judge, from the far too limited figures presented and those added by Glading (1938: 337) for 1936–38, that plenty of natural counterbalancing within the usual framework of density and phase effects did take place.

Rates of summer gain of the Hungarian partridge in the northern United States showed the same tendencies toward inverse ratios found in bobwhite gains, subject also to modifications through the presence of pheasants and conceivably of bobwhites (Yeatter, 1934: 77; Yocum, 1943: 195; Errington, 1945: 19, 24–25).

Partridge management in the Old World traditionally has called for strict repression of predators. Data holding up under critical appraisal have been virtually impossible for me to find, but the British writers Middleton and Chitty (1937) have taken the view that, while reduction in the numbers of predators may at certain times allow partridges to reach very high densities, "there is a limit to the carrying capacity of an area beyond which the population cannot be forced" without habitat improvements. I am unable to evaluate, from Severtzoff's (1934) figures on *Perdix cinerea*, his statement that the percentage of young birds surviving a winter "appears to be very constant . . . 5 or 6 per cent of the total number of the young bred during the summer minus the birds shot . . ."

In the management as shootable game of European ptarmigans (*Lagopus* spp., including *L. scoticus*, the red grouse), "vermin control" also has been traditional. The value of the records on shooting bags, which for many areas extend over long periods of years, may be greatly lessened by unknowns and mixed variables, but one thing is plain: Very high densities were often attained, whether through, or independently of, "vermin control." That such densities may be biologically top-heavy is attested not only by the great losses from diseases and parasites reported on occasion but, in addition, by what looks like exceptional vulnerability to small mustelids, rats, and other predators of sorts that would be expected to take slight toll under more natural conditions.

Native-exotic relationships among British Galliformes, resembling those of pheasants and bobwhites in Wisconsin and Iowa, are suggested by Gladstone's (1937) records for a "carefully nursed beat" in Dumfriesshire. In one of two hunting seasons compared, 336 black game (*Lyrurus tetrix britannicus*) and 350 pheasants were produced but, in the other, the bag was only three black game to 697 pheasants. The low year for black game happened to be the same 1936 so prominent in the cyclic history of the ruffed grouse and other wildlife. If there were no cyclic chronology in the population status of the North American and the British forms, at least the figures would seem to hint of bird-for-bird substitution.

North American prairie grouse have demonstrated some renesting ability, although considerably less than bobwhites and pheasants. Yeatter (1943) wrote of the greater prairie chicken (*Tympanuchus cupido pinnatus*): "Indications are that in southeastern Illinois a comparatively high percentage of the females finally bring off broods successfully," in part because of renesting; he found little evidence of successful late renesting. Hamerstrom's (1939) data on this bird and on the sharp-tailed grouse (*Pediocetes phasianellus*) in central Wisconsin were similarly indicative. Cartwright (1944a) suggested that predation upon nests, by extending the effective annual nesting span of the sharp-tailed grouse in western Canada, could be an important biological safeguard against poor reproductive success due to spells of unfavorable weather. Prairie chicken populations observed in Illinois and Wisconsin have shown few summer gains in inverse ratio to spring densities (Errington, 1945: 17–19), but any such trends existing would at best probably have been badly obscured by variables resulting from smallness of observational areas, waning status of local groups, presence of exotic competitors (especially pheasants), and cyclic influences. Davison's (1940) counts of average numbers of young *T. pallidicinctus* per covey in Oklahoma, 1932–35, point to inverse ratios and phase effects like those of the ruffed grouse.

Published examples of heavy predation upon *Tympanuchus* spp. are about as inviting to speculation as they are informative. The celebrated attack of goshawks upon the heath hen (*T. c. cupido*) remnant on Martha's Vineyard in the winter of 1916–17 was preceded by a fire very destructive to the habitat in May, 1916 (Gross, 1928), but I am unconvinced that the two events, with a whole summer and fall between them, had significant connection. The goshawk depredations occurred, however, at the low of a general "game cycle," and a reviewer may legitimately wonder if

their severity did not reflect a depression phase during which the prey was unusually vulnerable. Roberts (1932: 303–304) quoted an example of a flock of greater prairie chickens being nearly if not quite annihilated by goshawks during the winter of 1926–27, at the low of another cycle.

It seems rather to be expected that competitive relations influencing vulnerability to predation may be less apparent between racially long-adjusted native Galliformes than between native and recently introduced species. Segregation of natives into their own environmental niches does not always look complete, however, as was evinced by the 1941–42 overflow of southern Wisconsin ruffed grouse into underpopulated bobwhite coverts. In different grouse ranges of northwestern United States, the sharp-tail habitat may be seen grading off into that of ruffed grouse, the ruffed grouse habitat into that of blue grouse (*Dendragapus obscurus*). In the north-central region, prairie chickens and sharp-tails replace one another with changes in human land use or ecological succession, and, at the edge and in the depths of the forested wilderness, sharp-tailed, ruffed, and spruce grouse (*Canachites canadensis*) occur in their respective habitats. Differential vulnerability was indicated by the Hamerstroms' data from central Wisconsin lands reverting from limited agriculture to favor sharp-tailed grouse over prairie chickens; despite the fact that the sharp-tails were about three times as abundant, prairie chicken remains were found in almost twice as many of the horned owl pellets examined (Errington, Hamerstrom, and Hamerstrom, 1940: 805).

The picture of predation and population imperfectly outlined by writings on such large Galliformes as wild turkeys (*Meleagris gallipavo*) (Mosby and Handley, 1943; A. S. Leopold, 1944), sage grouse (*Centrocercus urophasianellus*) (Girard, 1937), and capercailzie (*Tetrao urogallus*) (Severtzoff, 1934; 1935) does not seem to differ in major essentials from that applicable to smaller-sized grouse.

Of capercailzie, Severtzoff (1934) wrote: "The mortality in the years following those when the spring is favorable and the brood numerous will be high and after an unfavorable spring, the numbers of the brood declining during the summer, the mortality, probably in the course of the following winter, will be less. As a result of this the increase in the number of the adults goes on with greater regularity owing to inverse fluctuations in the intensity of the mortality of the brood at an early and at a later age. The biological aspect of this . . . is hardly known, but the fluctuations in the mortality rate probably depend on the changes in the number of predators. The curves showing the shooting off of predators correspond to the curves in numbers of the game. It is chiefly the young birds, which have not yet attained their full maturity, that are caught by . . . predators, while the older birds escape them more easily." Irrespective of the challengeability of the frequently observed simultaneous abundance of predators and prey being a criterion of the population effect of predation, the rest of the above quotation seems to fit into the data so far collected from gallinaceous game.

As a rule, fewer individuals of the larger species seem to be taken by predators, but this may only reflect generally lower densities of prey.

PREDATION AND POPULATIONS OF BIRDS OTHER THAN GALLIFORMES

Let us now seek added perspective through reviewing the evidence afforded by non-galliform birds, first going up the phylogenetic scale (American Ornithologist's Union, 1931), then down.

Birds Phyletically Above the Galliformes

Sooter (1941) found the laying span of the coot (*Fulica americana*) in Iowa to be ample for effective renesting, which was both experimentally induced and strongly indicated circumstantially. His high rates of success for nests (91 per cent of 104 in 1936 and 77 per cent of 347 in 1937, without differentiation of renestings) look counterbalanced by a high (about 70 per cent) juvenile mortality. In view of his average of seven coot nests per acre in the plant associations most favorable to the birds on his principal area in 1937 and of the recent January inventories of the U. S. Fish and Wildlife Service (mimeographed leaflets) giving the continental numbers of coots at about 20 million, this species could be close to "saturation" levels for its existing habitats and accordingly may be expected to draw the severe predation that it does (Bennett, 1938: 70; Errington, 1943: 832; Errington, Hamerstrom, and Hamerstrom, 1940: 797–798, 845–847).

Young of the Charadriiformes may suffer conspicuously from predation, and Darling (1938: 70, 76) concluded that the better reproductive success noted for large colonies of the herring gull

(*Larus argentatus*) in the British Isles was due to a "nearer approach to synchronization of the breeding cycle," leaving a shorter period of exposure to predators of a colony's eggs and helpless young. Density reactions in the colony-nesting terns varied from the "Darling effect" (Bullough, 1942) to lethal manifestations of crowding (Murphy, 1936: 1129; Austin, 1946) and to wholesale abandonment of nesting sites as a psychological accompaniment of crowding by expanding gull colonies (Crowell and Crowell, 1946). Shore-birds are usually considered lightly victimized by predators, which in part doubtless reflects the low breeding rate of the group (a single small brood annually, with the known exception of the European woodcock (*Scolopax rusticola*) having two annual broods (Steinfatt, 1938) and the limited chances predators have to prey upon them during vulnerable stages. When circumstances really invite predation, shore-birds may be preyed upon about as much as any birds of similar sizes and densities. Brown (1939) wrote that British lapwings (*Vanellus vanellus*) and curlews (*Numenius arquata*) (at breeding densities near a bird per seven acres and one per 30 acres, respectively) "commonly hatch out four nestlings, yet the average brood reared by either species seldom exceeds two young and with many pairs it is only one young"; material losses were observed from predation as well as from weather and accidents. Studying breeding densities of the American woodcock (*Philohela minor*) of around a bird per 15 acres in Maine, Mendall and Aldous (1943) found a remarkably low juvenile mortality (not exceeding 10 per cent), but nest losses averaged nearly 40 per cent over the six-year period, 1937–42. This certainly suggests effective intercompensation in the loss rates.

The losses for these woodcocks were highest in 1937, a year of "about average" weather and with populations slightly above average for the area. The year 1937 was also noted for poor productivity of common terns (*Sterna hirundo*) along the Maine coast (Palmer, 1938). Palmer mentioned the possibility of cyclic changes independent of adverse weather (to which losses were largely ascribed) but with, in my opinion, overemphasis upon gross fluctuations as criteria.

Renesting, at least in response to early nest failure, appears to be of general occurrence in the mainly passerine "song birds," and we may judge that these lessen the population effect of the variable, often heavy, losses suffered through predation. Further intercompensations are reflected by inverse ratios between breeding season densities of adult birds and rates of increase. Erickson's (1938: 311) statistics for wren-tits (*Chamaea fasciata*) on 16.7 acres in California, 1932–33, show total populations of 76 and 75 birds after the breeding seasons, following March populations of 45 and 39 birds, or rates of gain in typical inverse ratio. McClure (1942; 1943) obtained comparable data on mourning doves (*Zenaidura macroura*) in southwestern Iowa, 1938–39; although he ascribed a lowered productivity in 1939 to storms, both of two published versions of population figures show the numbers of young leaving nests to be in inverse ratio to breeding densities.

Among the Strigiformes, the horned owl dominates the avifauna of extensive areas. Where not excessively molested by man, Baumgartner (1939) found its breeding densities appearing pretty much self-limited (at from one to three pairs per square mile in the best range); and, while the smaller owls may be abundant in a locality dominated by horned owls, they tended to keep by themselves. Direct predation by horned owls upon smaller members of their order looks quite severe (Errington, Hamerstrom, and Hamerstrom, 1940: 794), but the population effects thereof are undemonstrated.

Nice's (1933–34; 1937; 1943) detailed investigations of song sparrows (*Melospiza melodia*) unfortunately lack data on post-breeding populations. Taking percentages of eggs producing young as a criterion of reproductive success—which is by no means wholly defensible (Errington, 1942)—we find the percentages occurring not only in inverse ratios to breeding densities but also reflecting adverse modification of the nesting habitat for a series of years and possibly a "cyclic low" in 1936 (Errington, 1945: 26–27).

Bearing further on the question of depression phases are reports of members of the Eastern Bird-Banding Association of an "unprecedented scarcity of birds, notably the smaller species" in the winter of 1936–37 (Worth, 1937), and Chapman's (1939) data on tree swallows (*Iridoprocne bicolor*) in Massachusetts showing productivity in what appears to be "normal" inverse ratios to breeding density in 1934 and 1935 and a different set of inverse ratios during a less favorable phase in 1936 and 1937. Kendeigh and Baldwin's

(1937: 100) figures on the numbers of young of the house wren (*Troglodytes aedon*) plot only roughly in inverse ratio to adult densities, 1921–34, but, if Kendeigh's (1944: 85–86) revised sets of figures on adult birds be substituted, the inverse relationship becomes clearer, with the production rates for 1926 and 1927 remaining farthest out of line. These "off points," which are low for the adult densities involved, coincide with the low of the general "game cycle" preceding the better observed one of 1936–37.

Years ago, Potter (1915) observed near Camden, New Jersey, that the "Robin [*Turdus migratorius*] and Song Sparrow with one exception, exhibit the smallest number of [nesting] successes, yet these are the two most numerous native birds inhabiting the locality . . . ." That robins also suffer quite substantially from general predation is perfectly apparent, and Black (1932) concluded an account of a winter roost in Arkansas with a statement that the birds, by banding together, "open themselves to the united attack of every possible enemy for miles around." In instances like the latter, it is not clear how much the predation may be a function of density or may be merely borne, in the main, by the straggling, crippled, sick, or otherwise handicapped individuals characteristically to be found where immense flocks congregate. Granted that the confusion generated by large numbers may confer an advantage in escaping attacks by predators (Miller, 1922), and that predators may have more difficulty in sneaking up on a watchful flock than upon a lone bird, conspicuous aggregations certainly do attract flesheaters.

As to actual predation suffered by a population of small birds, Allen (1924) found that at least 98 birds of 24 species had been killed by the parents of a family of screech owls of a New York sanctuary during eight weeks in 1922 without much visible change in the numbers of birds living and breeding locally. Concluding, he wrote: "In making the statement that the total bird population of the area under consideration was not materially affected by the inroads of the Owls, I do not wish to minimize the destructiveness of the [latter] birds. It may well be that, had it not been for the Owls, there would have been a very substantial increase in the bird population."

In view, however, of the automatic adjustments revealed by more recent data and of Allen's own appraisal of the role of chance in determining what prey was taken, the bird victims may be suspected of representing chiefly the equivalent of a top-heavy, highly vulnerable and expendable part of the fauna. The fact that many of the birds killed were members of established breeding pairs, instead of the offspring thereof or victims taken directly from unmated surpluses, need not invalidate such a thesis. Little enough is published concerning the reservoir of unmated birds contributing replacements (sometimes with astounding promptness) when members of pairs are lost, but Kendeigh (1941: 44–46) has depicted the situation in the house wren. From his description of the behavior of non-breeding, but potentially breeding, birds, we may judge that not only did they frequent the less attractive habitats ("where nesting is usually not attempted") but also that they increased the territorial activities—and presumably the vulnerability—of the nesting birds. Hence we have what looks like considerable instability, relief from which could tend to occur through elimination either of the fringe-dwelling non-breeders or of sufficient numbers of nesting birds to draw the non-breeders into partly vacant territories, to become nesters in their turn.

More on intercompensatory trends is suggested by Smith's (1943) data on red-winged blackbirds (*Agelaius phoeniceus*) nesting in the vicinity of Chicago. If one considers that the predatory biota mentioned is impoverished in comparison with the populations of hawks, owls, mustelids, etc., often occurring about red-wing marshes a few hundred miles to the west, the recorded predation looks severe; and the thought may be advanced that the habitats may have been filled close to capacity by the breeding densities of the red-wings. For the two types of habitats compared, "A" had 122 females and an unknown number of males in 1940 and about 110 females and more than 40 males in 1941. In parts of "the B marshes . . . studied in both years, where conditions were comparable the total populations were 68–71 adults for 1940 . . . 79–81 for 1941." From these figures it may be judged that the adult populations for all comparable areas studied, regarded collectively, were similar during both years, with the 1941 decline of the "A" breeders being counterbalanced by the greater number on "B" during that year. Vital statistics are not given for 1940, but, in those of 1941, we see that the percentage of mortality through egg losses from predation in the "A" group (38.3 per cent) was appreciably lower than in the "B" group

(51.1 per cent); yet this was largely offset by a higher percentage of loss being due to predation upon nestlings in "A" (31.3 per cent) than in "B" (24.5 per cent). Averages of 2.17 and 2.14 young were fledged per "A" and "B" adult, respectively, although the reproductive success of the second brood was significantly higher in "A" than in "B".

Thirty-six nests and at least 10 additional pairs of British nightingales (*Luscinia megarhyncha*) were noted in a one-mile radius in 1934, a year of unusual abundance (Mayall, 1934). Egg and brood losses were "very marked. . . . Vermin of various sorts have been almost the sole cause of this destruction. Mice have sucked the eggs, while stoats and rats have devoured the unfledged young. . . ." But the losses mentioned ("Out of seventy nests . . . the contents of at least twenty-five have perished") would seem no greater than those to be expected for a high population of passerine birds almost anywhere.

Interspecific competition among native "songbirds" may or may not appear to have a depressive influence on populations. The phenomenon of nest "parasitism" by the cowbird, *Molothrus ater*, deserves thought. [For a standard reference, see Friedmann's (1929) monograph on cowbirds; also Chance and Hann's (1942) recent comparison of "parasitism" by cowbirds and European cuckoos (*Cuculus canorum*).] Michigan oven-birds (*Seiurus aurocapillus*) studied by Hann (1937: 219–220, 224–225) showed productivity in inverse ratio to adult densities, 1934–35, when productivity on the same tract of land was reckoned in terms of young oven-birds plus "parasitic" young cowbirds produced per adult oven-bird (Errington, 1945: 27). On the other hand, from my plotting (Errington, 1945) of Nice's (1937) data, it could be contended that the productivity of the cowbird might be superimposed upon, without really lowering, the productivity of the song sparrow hosts. Unanswered is the question of whether reduced nesting and fledging success, when actually resulting from cowbird "parasitism," may not be offset by increased security later on.

In Kendeigh's (1944: 89) data on passerine nests on his Ohio area, 1925–39, only a slight if any relation may be seen between numbers of nests of the different species, which takes us to the special case of house wren destruction of eggs of other birds—an inspiration for many an acrimonious page in the literature (Sherman, 1925; various Writers, 1927). After reviewing interspecific conflicts of this wren, Kendeigh (1941: 34) accepted the anti-wren testimony as being "generally well within the realms of possibility. Even if all accusations could be verified, nevertheless there is very little evidence that the house wren affects the established population of any species over a period of years, unless it be with the Bewick wren [*Thryomanes bewickii*]. The northward dispersal of this species appears to be hindered by the house wren, which in turn is probably limited in its southward distribution by the Bewick wren . . . .After 25 years of having a high population of house wrens nesting each year on Hillcrest, there is no sign of diminution of other species."

In Europe, Palmgren's (1932) findings on the segregation of goldcrests (*Regulus regulus*) and willow-tits (*Parus atricapillus*) may remind one of Price's (1935) on chiffchaffs (*Phylloscopus collybita*) and willow-warblers (*P. trochilus*). The figures on adult populations and broods of *Phylloscopus* on 500 acres of land surveyed, 1928–35, however, show somewhat more of an inverse relationship for the two species collectively than for either singly. Disadvantages in using numbers of broods as an index of reproductive success should be considered, as well as the variables due to segregation in different habitats, but there remains a debatable suggeston of mutual depression.

Nice's (1937: 222–223) data on the total passerine faunas on her main area for the 1930–31 and 1934–35 periods reflect the environmental changes of the latter years, but the breeding populations of song sparrows and of Passeriformes, collectively, changed little during either period—which, of course, does not alter the fact that numbers of breeding pairs of some species did fluctuate inversely with each other. The 1924–33 censuses of nesting birds for another area in Ohio showed a greater year-to-year uniformity in collective numbers than in numbers of the common individual species (Hicks, 1935).

The spread of the English sparrow (*Passer domesticus*) following its introduction in North America has given rise to a tremendous amount of critically inferior evidence as to its displacing native species and to a lesser amount that appears reasonably convincing (Kalmbach, 1940: 60–61). As much could also be said of the starling (*Sturnus vulgaris*) on this continent. It seems likely that both of the above species may exert a depressive

influence on "song birds" resident in their newly acquired range comparable to that of the ring-necked pheasant on the bobwhite in north-central United States, probably less through conspicuous physical conflict than in other ways that are more benign to view though inexorable in net effect.

Birds Phyletically Below the Galliformes

The Falconiformes furnish additional examples of populations doubtless limited by territorial intolerance. Despite the fact that hawks as well as small owls may suffer from horned owls, the big red-tails (*Buteo jamaicensis borealis*) may nest in the same wood-lots of the north-central United States, the two species maintaining between them a sort of balance and perhaps acting in the territorial sense as mutual depressants (Errington, 1945: 6–7). But even a Cooper's hawk displaying toward a horned owl a ferocity comparable to that of its larger relative, the goshawk, was still not deterred from nesting in the vicinity of the owl nest (Bent, 1937: 121, 134–135); and despite pronounced territorial behavior in the duck hawk (*Falco peregrinus anatum*) Hickey (1942) did not find its competition with other species of predatory birds "to be significant from a population viewpoint."

Summing up the evidence on the raptorial orders, Strigiformes as well as Falconiformes, we can see what looks like a general tendency for maximum densities to be self-limited. For all of the "dog-eat-dog" predation and interspecific intolerances to be noted, intraspecific intolerance in one form or another seems to be a basic mechanism underlying the regulation of their numbers. Superimposed are such factors as disease and cyclic influences, the latter of which may include those operating secondarily through a cyclic reduction of essential food animals, as in northern wilderness regions (Elton, 1942). The predation suffered by the raptorial birds seems to remain centered upon the immature, the occupants of marginal environment, the surpluses, etc., essentially as it does in populations of more typical prey.

Reproduction in ducks and geese, besides being affected by local and seasonal variables, differs greatly with the species. At one extreme, the mallard (*Anas platyrhynchos*) has an immense breeding range, considerable renesting ability, and an effective combination of wariness and adaptiveness. The blue goose (*Chen caerulescens*) is abundant in what constitutes its range, yet nests in a few thousand square miles of northern Canada where the season is not only short but also marked by much non-breeding (Soper, 1930). The blue-winged teal (*Querquedula discors*), with breeding grounds in temperate North America, may renest over a period of many weeks (Bennett, 1938: 57–59)—a statement also somewhat true for the redhead (*Nyroca americana*) (Low, 1945: 47–50). For that matter, most ducks nesting in southern Manitoba have rather extended nesting periods (Hochbaum, 1944: 94). Only the earlier renestings in such late-nesting species as the lesser scaup (*N. affinis*), however, can result in young developed enough to migrate before the freeze-up in the northernmost breeding grounds. (Desertion of females by males with advancement of incubation tends to restrict the period of most effective renesting in wild ducks to the early weeks of the laying season, anyway.)

The crow (*Corvus brachyrhynchos*), much publicized as a destroyer of duck eggs, is very ready to take advantage of the dropped eggs of the prenesting period, of ill-concealed early clutches, of nests deserted or exposed because of mowing or other emergencies. Moreover, Kalmbach (1937), in a study of crow-waterfowl relationships in the Canadian Prairie Provinces, where the crows have greatly increased with agricultural development, observed that duck nests appearing best concealed to human eyes suffered the most severely. He attributed the heavier raiding of the earlier duck nests no more to vulnerability than to the physiological needs of the crows during their own reproductive span. His observations had counterparts in those of later investigators in the north-central United States and in Maryland; there also seemed to be a correlation not only between crow depredations and the early-season availability of duck nests, but also between crow densities and the percentages of duck nests destroyed by crows on different areas (Hammond, 1940). But mallards nesting on the Kellogg Sanctuary in Michigan had equally high nesting success, 1933–34, whether crows were killed or unmolested (Pirnie, 1935: 70).

As to intercompensations, Kalmbach (1937) wrote, "It is possible also that if the crow should be eliminated, other factors, now more or less inconsequential, might react to an increased yield of waterfowl and become correspondingly more potent suppressive agencies." This is further borne out by data presented in one of his later

writings (1938) showing that losses of duck nests from the principal predators on the Canadian areas, 1934–35, were similar in 1936 on a North Dakota area except that the North Dakota losses occurred through the medium of skunks instead of crows; in 1937, following experimental trapping of skunks, losses from the skunks were greatly reduced, with evidence of partial counterbalancing through increased losses from other factors. Furniss (1938) found practically the same percentage of Saskatchewan duck nests hatched in each of two years—1935 and 1937—despite much variation in the percentages of nests lost by different species through different agencies. On the Bear River marshes of Utah, the egg loss from predation in 1937 was given as less than seven per cent for duck nests averaging about one per acre, though the losses from all agencies amounted to about 30 per cent (Williams and Marshall, 1938).

The late season nests of Kalmbach's Canadian areas were most successful in hatching out young, but Cartwright (1944a) pointed out that the drying up of shallow waters in midsummer "may be regarded as normal over much of the agricultural region of Manitoba, Saskatchewan and Alberta" and that the later the hatching, the more the losses of flightless young from drought exposure will be aggravated.

Further appraisal of possible intercompensations reflected by the above data is discouraged because of the lack of precise information on year-to-year densities for different areas and by variables resulting from pronounced changes in water levels and shifts in nesting populations. And there are the big questions of whether differences in the survival of young may have offset differences in nesting success, and whether the low of the general "game cycle" may not have had its manifestations in the fortunes of the ducks.

The evidence currently available for California quail and a few other species suggests the influence of a cyclic low in the western United States coming about a year later than the low years, 1936–37, of the "game cycle" farther east. Kalmbach (1939) cited a manuscript report by A. H. Trowbridge on Bear River, Utah, waterfowl: "In 1938 circumstances, as yet not fully explained, resulted in an unexpected predator problem involving skunks and magpies (*Pica pica*) in this area where previously there had been little trouble of this kind"; the total egg losses rose to 47 per cent. The same author also gave figures from manuscript reports by other federal workers on an Oregon and two Nebraska areas showing substantial to high nesting losses from predation in 1938, especially from bullsnakes (*Pituophis sayi*) in Nebraska; but around 70 per cent of the nests on three areas in Montana and the Dakotas were successful in 1938. Data published by Imler (1945) make it appear less likely that the severity of the 1938 Nebraska losses had cyclic connection, as duck eggs retained about the same dietary prominence for individual bullsnakes in 1942, when local populations of both snakes and ducks were much lower.

Bennett (1938: 92) wrote of the blue-winged teal on his principal area in northwest Iowa that the "nesting population 1932 to 1936 remained about the same in habitable environment," but the habitable environment varied with the year, in 1934 having been reduced about 75 per cent through drought and overgrazing by livestock. The 1934 season was one of unusually heavy nest losses (chiefly through non-predacious agencies) followed by an unusual amount of unsuccessful late renesting. Averages of young accompanying adult females were similar for comparable periods of each of four rearing seasons (see his pp. 73–74), including 1936, when many vertebrates of the north-central region reached their cyclic low.

A nearly extinct species might hardly appear a very promising source of data on density and phase depression, but the published figures on the trumpeter swan (*Cygnus buccinator*) are most suggestive. Hull's (1939) tabulated counts of grown swans and cygnets on the Yellowstone and Red Rock Lakes areas of Wyoming and Montana (the entire occupied breeding range in the United States) show depressed rates of gain in relation to densities in 1936 and typical-looking inverse ratios for 1937–38. The coyote was designated as the outstanding enemy at Red Rock Lakes and was subjected to "rigid control" in behalf of the swans, yet, by 1944, Delacour (1944) reported that "the increase has been slowed up or even stopped during recent years. Evidently the Red Rock Lakes are reaching their population limits." The 1944 rates of increase—11 young from 44 adults for the Yellowstone and 62 young from 169 adults for the Red Rock Lakes—are just about what the curves outlined by Hull's data might lead one to expect for the adult densities on the respective areas.

January inventories of North American Anseri-

formes given in mimeographed leaflets of the U. S. Fish and Wildlife Service (formerly Biological Survey) have ranged from about 27 million at the beginning of the decade, 1935–44, to about 105 million at its end. Variables introduced by region-wide droughts and other emergencies would make appraisals of net gains between times of spring and fall migrations most dubious, even were reliable figures on fall (pre-shooting) populations far more adequate than they are. Perhaps Cartwright's (1944b) summaries of enormous numbers of wild duck brood counts for western Canada, as of the last week in July, 1935, and 1938–42, may be as indicative of productivity as any existing statistics, although these are neither free from the shortcomings of brood counts (Bennett, 1938: 72–73; Hochbaum, 1944: 160–161) nor the influence of emergencies. In these counts, the chief suggestion of density depression appeared in 1942 (the last season of data in Cartwright's publication), following the first January inventory reaching the vicinity of 100 million ducks and geese for the continent; the 1942 average brood count for all species was 5.61, in contrast with previous averages between 5.96 and 6.3. Anonymous (1944) publicity relating to the 1944 breeding season following the highest January level gives a picture of exceptionally severe nesting losses both from predacious and non-predacious agencies. Brood counts of ducks over a large region are lacking for those interesting years, 1936–37, when so many other vertebrates had synchronously depressed rates of increase for adult densities, at least in part irrespective of climatic and environmental variations. Munro's (1939a; 1939b: 287; 1941: 133; 1943: 242) brood counts of numerous species of ducks in British Columbia, 1936–38, indicate that 1936, with its lower brood averages and presumably lower (judging from the continental situation) breeding populations, could well have been a time of cyclic depression.

A question here to be considered is whether possible density reactions are an interspecific or an intraspecific matter among waterfowl groups. Thriving of some associated species better than others at times when together they show density depression might be indicative of significant interspecific competition, but this cannot be adequately appraised from the largely non-committal evidence at hand. The mutual "parasitism" manifested by ducks laying in each others' nests—which Low (1945: 46–47) found to be conditioned by the amount of unsuccessful nesting—has its wasteful aspects and may be attended by much abandonment of clutches.

In his treatment of territoriality in wild ducks, Hochbaum (1944) described functions that were self-limiting in an intraspecific sense, though most species defending territories against their own kind were tolerant of ducks of other species except during "parasitic" intrusions. The distinction was made that, contrary to the behavior of birds generally, there was, with ducks, "little or no competition in placing nests," as the duck nests were usually outside of the territories. Maximum numbers of territories were determined to a large extent by edge effects in land, water, vegetation, and miscellaneous objects. The abundant mallards "appeared to completely fill their available territorial sites," while the greatly reduced canvasbacks (*Nyroca valisneria*) "did not occupy much first-rate territorial water. . . ."

Bennett (1938: 106–108) also had found edge effect phenomena very important in the ecology of wild ducks, and Leopold (1933: 131–132) had earlier expressed this as a law of interspersion applying to game of low mobility. Concerning mixed species of land and water birds in northern Illinois, Beecher (1942: 65) wrote: "It is demonstrated that population density increases directly with increase in numbers of feet of edge per unit area of the plant society or with the increasing floristic complexity of the environment in terms of communities per unit area."

The antagonism of coots and certain other water birds toward ducks has long been noted and a depressive significance attributed to it. Munro (1939a), in an effort to appraise this factor in relation to duck productivity, presented data on close to 650 brood counts of ducklings in British Columbia, mainly for July and early August, 1936–38, and from habitats having varying numbers and combinations of, or lacking entirely, coots, lesser loons (*Gavia immer elasson*), and Holboell's grebes (*Colymbus grisegena holboelli*). The average size of the duck broods remained much the same, irrespective of the presence or absence of the other water birds.

Ducklings do fall victim to a wide variety of vertebrate enemies as well as to non-predacious agencies—sometimes on a conspicuous scale. Heightened vulnerability of the semihelpless young may result particularly through drought

exposure, in which event predation may be mainly contingent upon discovery by the predators. This type of predation may also be strongly intercompensatory in net effect, for, if environmental conditions are sufficiently adverse to permit wholesale predation, the exposed ducklings may stand limited chances of surviving, anyway (Bennett, 1938: 68).

Bennett (1938: 70) suggested, and Low (1945: 59) reaffirmed the possibility that the comparative fewness of ducklings taken by minks in northwest Iowa may have been due to "buffer" action operating through the "abundance, unwariness and availability of the coot chicks," remains of which were seen in "practically every fecal dropping" of the minks deposited about the marshes from June 15 to July 15 of each year. The thesis would be hard to prove, and I have my doubts of its validity, chiefly because of once having had, and finding untenable, a similar one with respect to mink predation upon the young muskrats of the same areas (Errington, 1943: 831).

Adult ducks may suffer rather conspicuous predation. In the fall, wounded victims of shooters are notably utilized by wild flesheaters, and, in spring, some handicapped birds usually lag behind or die along North American migration routes. Perhaps most of the predation about large aggregations is centered upon such biological backwash, but there is plenty of evidence that the horned owl is capable of depredating with at least some regularity upon sound ducks (Errington, Hamerstrom, and Hamerstrom, 1940: 805–806), and other efficient predators are doubtless also able to do as much (Phillips and Lincoln, 1930: 195–196). During the breeding season, losses of adults through predation seem to be, as in most higher vertebrates, partly in consequence of preoccupation with mating, incubation, and care of the young. At other times, gregariousness of the birds, while assuredly advertising their presence to local predators, seems to have a distinct protective value, particularly if the wariness of the main flocks has already been sharpened by losses.

The European literature is, as expected, colored by sportsmens' and gamekeepers' opinions on the predation to which ducks and geese are subject. Changes in the status of these birds following human repression of predators, or the lack thereof, appear most pronounced (Berry, 1939: 160–163); but, here again, many variables, including possible effects of ecological or phase changes, are wholly impossible for a non-resident reviewer to dissociate, and the numerical data do not permit critical comparisons. The situations depicted in broad terms leave an impression that predation has a severity seldom witnessed in North America, except about establishments where game is artificially propagated or in other places characterized by extreme availability of prey.

Intrusions by predators into lands formerly free from them have special philosophical interest. The black-bellied tree duck (*Dendrocygna autumnalis*) nested on the ground, "even in the open fields," in Jamaica before the introduction of the mongoose (*Herpestes griseus*); in "a very few years . . . these destructive animals [the mongooses] almost succeeded in exterminating the species . . . but the survivors took refuge in different nesting sites, perhaps in deep swamps. Then they gradually increased in numbers" (Phillips, 1922: 171–172).

One might be tempted to speculate as to how much the comparatively benign (or, at any rate, endurable) predation to be witnessed today over so much of the waterfowl breeding grounds of midcontinental North America could be a resultant of a long succession of naturally occurring intrusions by enemies and the redeeming adjustments made by population remnants surviving them. Among the predators native to the prairie States and Provinces are surely hunters—the canids and mustelids—as diligent and capable as any introduced elsewhere. Unquestionably, the prairie ducks bore great predation at times when conditions favored it (see Bent's (1923: 78–79) reference to havoc resulting from the presence of a coyote on a duck-crowded island of a Saskatchewan marsh in 1906), yet the ducks coinhabiting the prairies with their ancient enemies were marvelously abundant at the time of the advent of the white man. The recent spread of the coyote into waterfowl breeding grounds far outside of its original range (Phillips and Lincoln, 1930: 189) might well be the sort of thing to force some species either downward or into new adjustments.

The Arctic fox (*Alopex lagopus*) is as bona fide a native in its circumpolar range as are the species of ducks and geese that nest there. Notes supplied Bent (1925: 201, 260) by F. C. R. Jourdain expressed the view that the habits of certain geese nesting on islets and steep cliffs of Spitz-

bergen had been evolved through association with the foxes, as the relative inaccessibility of nesting groups of other Arctic waterfowl would also suggest. Foxes reaching some of these isolated breeding spots committed depredations of great severity on such ducks as eiders (*Somateria* spp.), even when only a single fox was marooned on an island (McNeile, 1941). Lewis (1923) wrote of an invasion of Arctic foxes of a Labrador area in 1922 that destroyed large numbers of the eider nests on all but the most isolated islands and, in combination with adverse weather, left the ducks little to show for the season's breeding. Similar destruction during 1938, another year of exceptional abundance of these foxes, was reported for northeast Greenland (Bird and Bird, 1941).

As an example of a reversed trend: In the Falkland Islands, since the extinction about 1875 of the "endemic wild dog commonly known as the Falkland fox . . . there seems to have been a change in habit of certain waterfowl which were once confined to outlying islets, but which have now added the moorlands of the main islands to their breeding areas" (Murphy, 1936: 206).

To a considerable extent, the more drastic consequences of observed predation upon waterfowl by native enemies may but reflect the weak territoriality that Hochbaum (1944) found in duck females choosing and caring for their nest sites. Notable concentrations of nests may be found in areas where large populations have access to limited nesting places. Congreve and Freme (1930) described conspicuous depredations by ravens (*Corvus corax*) upon egg clutches massed on high ground after the flooding of an Icelandic marsh. Such massing is not without its parallels in galliform behavior. Iowa old-timers interviewed by Leopold (1933: 56) during a game survey told of "the great concentrations of prairie chicken nests which followed the prairie fires of pioneer days. Several said one could not walk across the unburned patches of grass without crushing chicken eggs 'at every step.'"

Most ducks tolerant of, or displaying propensities for, nesting in dense concentrations may not be truly colonial birds, but theirs are some of the problems of colony breeders so long as they behave as such; and they must resort similarly to isolation for protection against enemies not otherwise to be coped with. Effective isolation from the hosts of gulls, skuas, etc., that congregate about them (Bent, 1925; Murphy, 1936; Gross, 1945) is another thing, especially when the predators are able to take eggs and young much as they seem to wish. Bergman's (1939: 112–113) finding that eider ducks on Finnish Islands lost many more nests from predation when gulls were absent, than where the presence of nesting gulls afforded greater protection from crows, reflects adjustment at least to the extent that the ducks and other birds actually chose to nest amid the gulls. Under crowded conditions, however, a high degree of wastage would seem inevitable, and it is quite probable that the steady day-by-day losses have their intercompensatory aspects, even though our information may be insufficient to demonstrate anything more than the facts of heavy predation and of the coexistence of predators and prey.

From the literature on subanserine water birds, glimpses of patterns of basic vulnerability and automatic adjustments may be obtained. Renesting is very frequent (Murphy, 1936; Bergman, 1939: 81–85); intraspecific competition and intolerance show much diversity; and the life equations of many species do not seem entirely free from influence by "cyclic" phases having no perceptible relation to weather or food differences.

The white stork (*Ciconia ciconia*) has been a much investigated bird in Europe since the beginning of the century (Schüz, 1936, 1938). Published data hint not only of density depression of rates of increase but also of what might have been cyclic depressions in 1928–29 (Brinkman, 1934; Schüz, 1936) and 1937–38 (Lang, Emeis, Schüz, and Drost, 1938; Hornberger, 1938, 1939)—about a year later than the low of the "game cycle" in the north-central United States. Relating to other European Ciconiiformes, Elder (1945), in a review of a report by Alexander (1945) on nest censuses in heronries of the British Isles (which had been in progress nearly two decades), called attention to the data seeming to afford "another interesting example (though unstated) of the concept of inversity. . . . If there is no increase in breeding populations of Herons following five successive mild winters, low infant survival during this period is indicated; if the population builds back to nearly normal in only two to three years following reduction of 32% in population as a result of several severe winters—high infant survival is suggested . . .".

Exceptions notwithstanding, Murphy (1936: 907–908) indicated that: "It seems to be characteristic of the vultures and gulls to attack at the

edge rather than in the midst of a [guanay, *Phalacrocorax bougainvillii*] colony, and thus tend to annihilate projecting portions and small outlying groups." In this connection, Vogt (1942: 53) plotted a "curva de segurida de los guanayes" from data on vulnerable circumference in relation to area of a colony. Something of the converse is suggested by the observations of Baker (1940) on Texas herons. Crows destroyed practically all of the nests of about 1,500 little blue herons (*Florida caerulea*) and 3,000 snowy egrets (*Egretta thula*) concentrated on less than an acre of bottomland, at the same time doing much less damage to the nests of about 1,750 night herons of two species (*Nycticorax naevius* and *Nyctanassa violacea*) dispersed over about 300 acres. And the blue-footed booby (*Sula nebouxii*), though not strictly colonial, nested in great numbers at Lobos de Tierra, Peru, where its mortality was judged slight, despite the activities of its "arch enemy . . . the equally aboundant" kelp gull (*Larus dominicanus*) (Murphy, 1936: 836-837, 1062).

Even patently "normal" depredations of native enemies on some colony-nesting water birds may be spectacular enough. Ekblaw (Bent, 1919: 220–221) found that the dovekie (*Alle alle*), in "vast colonies on . . . northwest Greenland slopes," constituted staple food for foxes, gulls, and falcons. Of the young of the short-tailed shearwater (*Puffinus tenuirostris*) near Tasmania, Murphy (1936: 676) wrote "Mortality from diurnal enemies, or as a result of physical accidents on the rough terrain, is very high, but the surviving chicks cover the neighboring seas in . . . black flocks." This author (see his p. 625), who was "forced to wonder how the unfortunate whalebirds [*Pachyptila* spp.], which lay but a single egg, and which suffer so heavily from their enemies, can still exist in such incalculable numbers . . . ," later inferred that their chief hereditary enemies, the skuas, were mainly successful in capturing individuals either coming home to their land burrows too early in the evening or being "a few fatal moments late in getting away at daybreak." Then, again, there may be periods when large numbers of prospective victims may happen to become highly vulnerable, such as chicks of the Manx shearwater (*Puffinus puffinus*) reduced to torpidity with the approach of daylight before completing their initial journey from burrows to ocean (Lockley, 1930).

Enemies of colony-nesting birds, besides committing the usual types of depredations, naturally take advantage of special opportunities, notably when eggs or young are left exposed or unguarded or otherwise made available because of human intrusion. The behavior of many of the victimized species with respect to eggs and young seems so bound up with "imprinting" (Lorenz, 1935, 1937) and so stereotyped in the face of dangers (Murphy, 1936) that a minimum of real adaptability can be expected of them. Atlantic murres (*Uria aalge*), studied by Johnson (1938), were afflicted by a fear conditioning that made excessively disturbed colonies progressively more susceptible to predator raids, although their "ability to re-form a breeding colony and produce a new crop of eggs" surely represented an important adaptive response. (A like conditioning may underlie the behavior of gulls harried by crows in Maine (Herrick, 1912): ". . . when greatly disturbed the whole company will ascend to great heights or go out to sea, leaving their homes and tender young to the mercy of the enemy.")

The inability of some oceanic birds to maintain their colonies against rats and other introduced mammals which overrun island nesting grounds (Murphy, 1936) is not surprising. In commenting upon the destructiveness of feral dogs to the native fauna of the Galapogos Islands, Murphy wrote: "A particularly noteworthy characterization of these descendants of domesticated animals is their wildness, which contrasts amazingly with the utter confidence and lack of sophistication shown by nearly all of the autocthonous animals." Introduced birds as well as introduced mammals may prey severely upon native colonies—as the little owl (*Athene noctua vidalii*) upon storm petrels (*Hydrobates pelagicus*) on British islands (Hibbert-Ware, 1937; Lockley, 1938).

(To be concluded)

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to B. H. Willier, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, Homewood Campus, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

MAINSPRINGS OF CIVILIZATION

A review of *Mainsprings of Civilization*, by *Ellsworth Huntington*. John Wiley and Sons, New York; Chapman and Hall, London. $4.75. xii + 660 pp. 1945.

By George F. Carter, Johns Hopkins University. For more than forty years Huntington has studied the relationship of man to his environment. His oft-repeated thesis has been that climate acting upon human physiology is the principal determinant of man's achievement. This thesis of the natural dominance of peoples in certain climates and the retardation of peoples in other climates has had a great influence on popular thought in America. Huntington here presents the conclusions of a lifetime of study. He states at the beginning that his thesis is that the mainsprings of civilization are biological inheritance, physical environment, and cultural endowment.

The first factor is examined in a two hundred page section called "Heredity." Here the thesis is advanced that certain groups of people who have been subjected to strong selective processes, and then isolated either physically or socially, have by interbreeding become a fixed biologic group with specific mental traits. Such groups, called kiths, he finds have been extremely important in the advancement of man's culture. Examples of such groups are the Puritans, the Junkers, and the Jews. The second factor, physical environment, is examined at great length (four hundred pages) in a section entitled "Physical Environment and Human Activity." Here Huntington restates his arguments for the dominating influences of weather and climate on human activity and, hence, on the whole course of human development. The third factor, cultural endowment, is not separately discussed. This distribution of emphasis is significant.

It is difficult to criticize so large a work and impossible to do so in detail within the limits of a review. However, some of the major theses may be profitably examined both for their own validity and as examples of Huntington's methodology.

The concept of the kith is the key to the first section. This concept stands on two assumptions. The primary one is that character traits, or at least the tendency toward such traits as austerity, religious fervor, and academic or learned accomplishments, are inherited. A secondary one is that selection over a relatively short period of time of peoples for such characteristics, followed by biological isolation, will fix such superior traits. It is clear that the first assumption is the vital one.

Many will consider the Puritans not only Huntington's best example, but the best documented case. He shows that the voyage to New England was difficult and the first few years were very trying; that only a few thousands immigrated in a brief period and that the area was thereafter effectively isolated. The well known cultural achievements of the New England Puritans are then pointed out as the result of the establishment of this selected, biologically superior Kith. It is shown that the earlier families have accomplished most and that the later Puritan immigrants accomplished less. To Huntington this is clear evidence that the later groups were less rigidly selected. But in both cases Huntington assumes that biologically superior types derived from social and physical (through migration and colonization hardships) selection gave rise to this cultural flowering.

Genetically it seems doubtful that such short term selection as Huntington is here dealing with could produce the results he envisions. All of the stocks of mankind, and most especially European stocks, are genetically heterogeneous. No selection of thousands of individuals from such a stock could be expected to breed true for any trait, but would have a most diverse hybrid offspring. Rigid selection for biologically determined traits (in distinction to such dubious things as character traits) over a long period of time would seem to be necessary to fix inheritable tendencies.

Moreover, every effect Huntington ascribes to biological inheritance can be attributed equally well to cultural inheritance. Do Puritans emphasize learning, law, and religion because their genes so determine, or because their cultural background so determines? May we not better argue that the Puritan achievements are a product of the Reformation which dispensed with priests and stressed the education of the people so that they might interpret religion for themselves? With a social premium in a nearly closed society placed upon learning, is it not to be expected that individuals would accomplish much along those lines? Almost irrespective of their genes, would not individuals tend to conform to the social norm and gifted individuals probably make their contribution in terms of such learned endeavors? The decrease in accomplishments of the later Puritans could then be accounted for as due to the decreasing intensity of English Puritanism. The continuity of achievement by people of Puritan descent outside New England would then be an example of continuance in family lines of social and cultural values. The other kiths are equally readily accounted for on cultural grounds, and equally hard—or at times harder—to account for on biological grounds.

It seems that Huntington does not understand the nature of culture and is, therefore, unable to distinguish between cultural and biological causes and effects. This appears to be made clear on page 41, where he quotes from Melville Jacobs a statement that expresses very well the belief of most scientists concerned with these phenomena. Huntington, however, seems not to understand the problem. Yet his whole concept of the kith depends upon these distinctions being differentiated with great care. Since they are not, his argument that kiths are biologically superior groups is unacceptable.

It is true that Huntington is at pains to put in qualifying statements concerning his views. For example (p. 214), he represents his theory of the kiths as being a middle of the road view. He states that there is no direct proof that the Junkers as a group possess any distinct innate qualities or capacities different from those of other Germans. But, this being totally different from what he has argued, he hastens to add that he thinks that the Junkers *do* possess such hereditary differences. Qualifying statements are inserted throughout the book, but they are insertions, divorced from the main themes and immediately afterward disavowed.

The very long restatement of Huntington's views of the cyclic nature of climatic elements (heat and cold, precipitation and drought, storminess, etc.) cannot be dealt with in detail. Huntington considers it a mere fashion of our times that we tend to explain historic events and circumstances principally in terms of culture and economics (p. 139). He attributes this to a scarcity of knowledge concerning physical environment and heredity. We have dealt with Huntington's ability to distinguish between cultural and biological heredity above. With the permission of Dr. George Kimble of the Department of Geography of McGill University, I reprint below eight points in criticism of Huntington's meteorology (reprinted, by permission of the editor, from *THE GEOGRAPHICAL REVIEW*, 36 (1): 142-146, 1946):

1. It is by no means true that "the rainfall of tropical regions is almost entirely of the . . . convective or orographic type"; . . . air masses and their contiguous fronts play almost as large a role in synoptic analysis of the tropics as they do elsewhere.

2. The description (p. 331) of a typical storm is more ideal than real; for it is not at all usual for the wind to die down near the center of an extratropical storm, nor does modern dynamic meteorology know anything of "a neutral space near the meeting point" of tropical and polar air masses.

3. Polar air is frequently not dry (p. 369), and in summer over the continental United States it is often difficult to distinguish it thermometrically, at the surface, from tropical air.

4. It is misleading to speak of "the low barometric pressure arising from the tropical water that sweeps northward from the West Indies" (p. 384) as providing a highway by which many American storms cross the Atlantic to Europe; for the Atlantic storms are steered, not by surface controls, but by conditions in the upper atmosphere.

5. There is equally little justification for the statement (p. 388) that any of the cyclonic storms which reach Japan from the west have circumvented Southern Asia.

6. It is still highly questionable whether the concurrence of sunspot maxima and subnormal earth temperatures is due to some electrical or other effect of the sun, whereby "masses of air appear to be moved from lower to higher latitudes" (p. 517); for this condition would tend to damp down the westerly circulation of air in the mid-latitudes, and, as Rossby, Willett, and others have shown, a weak westerly circulation correlates well with subnormal cyclonic activity—a state of affairs more characteristic of periods of sunspot minima than of sunspot maxima.

7. So far as Western Europe is concerned, periods of unusual cyclonic activity are not conspicuous for extremes of either cold and heat or drought and flood (p. 606). Indeed, as Huntington himself points out (pp. 516-517), periods of maximum cyclonic activity coincide with periods when "the earth's surface tends to be relatively cool"; and it is axiomatic that the greater the frequency of such activity, the greater the number of rainy days and the shorter the interval between them. Actually, drought and extremes of heat and cold are much more likely to characterize anticyclonic spells of weather.

8. It is more than likely that the changes observed or inferred (p. 500) in the amount of ozone above a given locality are *not* the result of transport of air masses from Arctic regions, where the amount of ozone is normally large, to middle- or low-latitude regions, where it is normally smaller. . . . Furthermore, it is unlikely that the ozone is brought "downward from high altitudes" by vertical currents, since Dobson has demonstrated that the average height of the ozone layer does not change appreciably with the present amount.

From the above it becomes clear that Huntington is not master of the modern meteorological concepts which he attempts to use as causative factors for cultural phenomena. Most meteorologists and climatologists would probably consider our basic knowledge in these fields still too slight to attempt to build such far-reaching hypotheses as Huntington attempts on incomplete knowledge of such data as we do possess.

Huntington's work is superficially factual. Maps of the distribution of various alleged measures of civilization are shown. However, these factual presentations (based on census data, etc.) are then *interpreted* in terms of the impact of the physical environment. Cultural factors are either not considered or are misrepresented: e.g., that the American South is a rural slum stands out by any index. That the "South" coincides very roughly with certain climatic elements is obvious; that the impoverishment is climatically caused is an assumption only possible to one who chooses to ignore social, economic, and historic causes. For a more acceptable handling of this type of problem of climate, culture, and race, readers are referred to A. G. Price, *White Settlers in the Tropics*.

Typically, Huntington's ideas lift themselves by their bootstraps. The world map of climatic efficiency is based on the supremacy of the industrial groups. This is in itself a dubious value judgment based on the assumption that climate and culture are causally related to this extent or in this way. A world map of health resembles the map of efficiency. But health in the world today is largely a possession of those nations who have shared in the industrial revolution and the related progress of medical science. These two maps, and most of the similar maps, are but differing aspects of the result of the same historical accident (the industrial revolution), in no way shown to have been environmentally caused. In terms of man's history they represent a momentary condition that bears what may be but an accidental relationship to climate, with no guarantee that the relationship will hold for even another one hundred years.

There is finally the question of competence in handling data in many areas. For Americans it is easiest to test Huntington on American ground. In 1914 Huntington visited the Southwest, and with characteristic energy rapidly surveyed part of the area. He subsequently published his findings, which were then sharply attacked by the most competent men in that field. In this work, however, he returns again to this area to draw examples of the recent desiccation of arid regions and of the resultant failure of sedentary peoples. He thus finds it necessary to change the climate to account for the disappearance of the Hohokam culture with its large sedentary agricultural villages. In so doing, he is in complete disagreement with every major student of the area, past or present. Yet it is on such judgments that he builds up his correlations of culture growth and climatic changes around the world. His views of causes of agricultural changes in Peru are equally suspect. If his judgments in other areas are as weak, then his sweeping correlations of climatic and population shifts around the world are baseless.

One suspects that this is the case when one finds Huntington able to correlate redwood tree growth in California with nomadic movements in Eurasia. Dendrochronologists find little correlation between California redwood tree growth and Arizona pine tree growth. Foresters have found little correlation between redwood tree growth and rainfall. In Arizona it is necessary to construct at least three tree-ring sequences for the various parts of the state before one can get close correlations. Is it then likely that the tree rings of California redwoods can reflect the climatic changes of North Africa, Arabia, and Inner Asia? Can one use a single man's interpretation of history, that often places movements of people only within a century, to make such a correlation? And if one can explain some of the movements of later times in terms of cultural causes (e.g., the thirteenth century Mongol and Tartar movements that occurred in a period of favorable redwood growth), might not some of the earlier movements also be so accounted for if we had fuller data? Is not such a correlation then methodologically unsound and climatically improbable? At the very least, may we not say that such a proposition, theoretically so improbable, deserves much more careful treatment before presentation?

Huntington's work is often described as stimulating. In the hands of a mature scholar with critical training, it may be. It raises many problems, few of which are answered satisfactorily. Perhaps the value of Huntington's work lies in this opening of lines of inquiry. It is, however, poor material to put in the hands of students who may lack sufficient background to be critical of it. It seems almost dangerous to put such speculative material in the hands of the public. Little good will be accomplished if our people today are led to view all peoples in warm countries as incapable of technical and cultural achievement, and are encouraged to take a complacent view of the climatically predestined world dominance of the peoples of mid-latitudes.

REVIEWS AND BRIEF NOTICES

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

THE DIRECTIVENESS OF ORGANIC ACTIVITIES. *By E. S. Russell. Cambridge, England: at the University Press.* $2.00. viii + 196 pp. 1945.

"Directiveness" is a word which Russell adopts from C. S. Myers to indicate those activities of living organisms which are "directed towards end-states or goals which are normally related to the biological ends of self-maintenance, development or reproduction" (p. 3). He hopes by using a neutral word of this type to avoid the mystical implications of such words as "purposiveness" and "teleology" and to present the phenomena of directed activities in organisms as legitimate subjects for scientific investigation. The major portion of his book consists of a systematic description of various types of directed activities and the summarization of the common features of these activities in the form of empirical laws. In that he discusses side by side histogenetic and morphogenetic activities involved in development and regeneration, physiological phenomena of homeostasis, and animal behavior patterns, and points out interesting analogies between a wide range of biological activities, his book makes stimulating reading. He concludes that "behavioural action on the part of organisms and cells is only one of the methods by which biological ends are reached, that it is functionally equivalent to morphogenetic and physiological action" (p. 178), and thereby seeks to abolish any dichotomy between life and mind. Purposeful behavior, according to Russell, is but a specialized development of the directiveness which characterizes all organic activities.

However, in spite of his announced intention to avoid philosophical speculation and not to revive the old controversy between materialism and vitalism, in his enthusiasm for presenting directiveness as an outstanding feature of organic activities he makes many statements which leave him open to accusations of vitalism. His basic argument is that the directive activities he describes are recorded facts, and that any scientific investigation of biological phenomena should not lose sight of the relation of these phenomena to the maintenance of the organism as a whole. To treat them as "purely physico-chemical, to seek always for a causal-analytical explanation, and to analyse them without end, is to get bogged in a vast intricacy of unrelated detail, and to lose sight of the biological significance of these activities, their active relation to the life of the organism as a self-maintaining, reproducing, and developing whole" (p. 4). This is a rather grim picture of analytical biology, but it is in reaction to this type of materialism that Russell leans too far in the other direction, erecting what is in effect a dualism between living things and the inorganic world. Here he goes beyond the factual description of directive phenomena and insists that directiveness is an "irreducible characteristic" of living organisms. He praises the usefulness of mechanistic explanations of partial processes involved in a directive action but excludes the possibility of a mechanism being devised, no matter how elaborate, which would account for the organism as a whole. "It seems indeed fantastically improbable that the complex and self-maintaining organisation of even the simplest living things can be built up by the free play of inorganic forces as we conceive them; there must be in life some different principle at work, even though we can form no adequate concept of what it is" (p. 8). Russell does not avoid vitalism by leaving the "different principle" unnamed.

ROY GILLETTE

GENERAL BIOLOGY AND PHILOSOPHY OF ORGANISM. *By Ralph Stayner Lillie. University of Chicago Press, Chicago.* $3.00. 215 pp. 1945.

The words of an elder scientist are always of interest, whether or not we agree with the views expressed. To those who have read Lillie's contributions to the *American Naturalist*, the *Journal of Philosophy*, and *Philosophy of Science* in past years, it will come as no surprise to learn that the philosophy of the eminent physiologist is teleological. It may be summed up in part as follows:

> "The living organism is . . . psychophysical; the psychical reacts on the physical and vice versa . . . But the psychical influence is of a special kind and differs characteristically from the physical; it is the fundamental source of the selective, innovational, and integrative property of the organism; its essential quality may be described briefly as direction, aim, purpose—in a word, the teleological. There exists in the psychical a property of spontaneity; part of its determination is in the present and independent of the past, and also independent of present conditions external to itself . . . Accordingly, novelty and creativity (including 'free will') have their origin in that part of the organismic activity which is psychical rather than physical . . . Nature is a combination of random and directed activities; randomness . . . furnishes the basis for uniformity and stability in physical processes; and conversely . . . the existing diversification of nature, nonliving as well as living, . . . [is] evidence of directiveness . . . 'Teleology and mechanism are correlative rather than opposed.' " (pp. 196; 95)

The crucial question in any such philosophy is, as Lillie recognizes (p. 129), the question how the psychical factor can operate on and give direction to a physical system, since the psychical factor, qua psychical, cannot exert physical force. Lillie resolves the difficulty in a way that reminds one of the famous idea of Lucretius concerning the swerving of the atoms.

He is forced to assume that "the ultimate locus of psychical control, in the psychophysical system which is the living organism, is situated *internally to* or behind the elementary physical events (quantum transfers) which determine the direction of action in the physical field (p. 129) . . . We may thus conceive of the possibility of an intra-atomic directive action which is quite independent of the classical laws of energy" (p. 132). Given a non-spatial psychical factor providing "bias, preference, directiveness or purpose," the randomness of physical activity is changed to directed action. But Schrödinger has recently pointed out, in his book *What Is Life?*, that biologists who seek for purposiveness in the indeterminacy of the atom are pursuing a phantasm. Moreover, to argue for any essential relation between such an intra-atomic factor of directiveness and the human "free-will" is to ignore the magnitude of the problem. For if a psychical factor in the human mind sways an action, it would need to involve the determination, not of one quantum-transfer in a preferred direction, but surely of multitudes of quantum-transfers predominantly in the same direction. The problem, therefore, cannot be confined to the intra-atomic sphere.

Lillie's views lead him to suppose that mutation is also directed by the psychical factor (p. 47). I do not know of any geneticists who would uphold him in such a supposition. Nor is it in the least necessary in order to explain the directive aspects of evolution. Lillie's sweeping rejection of the natural selection of purely fortuitous variations as a sufficient explanation for the origin of the entire range of adaptive characters is arbitrary and quite opposed to the modern genetic theory of evolution. We need not assume that in guiding and directing development, genes exert any but a physical mode of action. Why then must one assume that directiveness in nature cannot be due to the physical but must be due to the psychical? That is the very point at issue! Yet Lillie clearly does assume this, over and over again. Physical activity, he says, is random in nature, while the psychical is "typically selective and directive"; . . . "such correction can be accomplished only by activity which is directive; i.e. controlled by psychic aim or purpose" (p. 178).

All of us, determinists and teleologists alike, must go on living daily as though we believed in free will. Sooner or later, if we have sufficient courage, we face this philosophical problem. Ralph Lillie has faced it. It must be confessed with true regret that he has not contributed much to its solution.

BENTLEY GLASS

LOUIS AGASSIZ AS A TEACHER. *Illustrative Extracts on His Method of Instruction, with an Introductory Note. Second Edition. By Lane Cooper. Comstock Publishing Company, Ithaca.* $1.50. xi + 90 pp.; 1 plate. 1945.

Younger American biologists especially will be grateful for this new edition, after a lapse of nearly two decades, of Lane Cooper's little book about Louis Agassiz. Since most present-day American biologists trace their scientific ("biological" seems the wrong word here) inheritance directly or indirectly back to Agassiz through T. H. Morgan, Wm. K. Brooks, David Starr Jordan, C. O. Whitman, Hyatt, Verrill, Burt Wilder, or any of a dozen others, any competent book about Agassiz will always have a special significance in this country.

The distinguishing and important feature of this book is that it consists largely of a compilation, from a variety of sources, of first-hand accounts by people who knew him of the words and actions of the father of biology in the United States. The temptation to quote is great, for Agassiz has left us a goodly heritage. William James remembers him telling his students to "Go to nature; take the facts into your own hands; look and see for yourself!" David Starr Jordan took down in his notebook in that famous summer of 1873 when Agassiz was lecturing at Penikese, "You cannot do without one specialty; you must have some baseline to measure the work and attainments of others. For a general view of the subject, study the history of the sciences." For the way Agassiz taught these principles to his students, the reader must turn to the book itself. Or would Agassiz throw this book out the window and insist that we turn to the men and women who practise what he taught?

GAIRDNER MOMENT

SCIENCE AND THE PLANNED STATE. *By John R. Baker. The Macmillan Company, New York.* $1.75. 120 pp. 1945.

In Great Britain there has developed in recent years a strong and vocal group of scientists who maintain, in Baker's words, that:

(1) Science exists to save the material wants of man.
(2) Central planning makes for efficiency, and scientists have a duty to press for its introduction in their own sphere . . .
(3) . . . They should press for the adoption of a scientific scheme of central planning in all departments of life . . . It is their duty to take an interest in party politics and to support . . . central planning under state control. It will also be to their advantage to ally themselves with the party that will gain power.

These views have been expressed most openly by J. G. Crowther in *The Social Relations of Science.*

In opposition, Baker speaks out forcefully and reasonably. He argues that scientists do not, and should not, work solely for material ends. Science, as truth, possesses intrinsic excellence and is an end in

itself. As a true liberal, Baker then considers the importance of freedom of inquiry to scientific research. He points out that there is a value in the overlapping of independent research, inasmuch as the surest confirmation of results is thereby secured, while independence and originality are most strongly encouraged. Numerous examples are given to support these generalizations. This is not to say that there is no place for teams in research—Baker argues only that they have a limited place and that much research is best carried on by the isolated worker.

In the next chapter Science Under Totalitarianism is examined. The U. S. S. R. affords the prime instance. The 1932–37 five-year plan for science, the Soviet genetics controversy, and the deficiencies of Soviet science alike point to the conclusion that "science can flourish only if free from state control." "The movement for free science and pure science is not political in any narrow sense. It includes liberals, conservatives, and socialists . . . It is only from believers in totalitarianism that we can expect no support. The central planning of science is essentially part of the totalitarian theory of the state."

In his last chapter, Baker discusses the duties of scientists to society. The primary social duty of a scientist is of course to make the greatest possible contribution to human knowledge, and to publish his results. Secondary duties he feels are: (1) the preservation of our scientific heritage, especially the spirit of science; (2) the encouragement of the amateur in science; (3) the recruiting of suitable persons into the profession; (4) the political defense of the principles of free speech, valid argument, and international cooperation; (5) honor for the uncommon man and provision of the conditions he must have in order to be creative; (6) kindness to the animals the scientist uses in his laboratory.

Scientists in America are also feeling the cleavage into opposing schools of thought over this vital question. Those who believe in the necessity of freedom of inquiry, freedom of speech, and freedom of publication will rejoice to have found so effective a spokesman. It is significant that, in our recent debates over the character of the proposed National Research Foundation, the great majority of American scientists united in the belief that while government support is desirable and necessary, it must not jeopardize the rights of scientific freedom we cherish, and without which the spirit of science dies.

BENTLEY GLASS

LABORATORY OUTLINES OF GENERAL BIOLOGY. *Third Edition.*

By William C. Beaver. The C. V. Mosby Company, St. Louis. $2.00 (paper). 268 pp. 1945.

This compendious laboratory manual, designed to accompany the author's text, *Fundamentals of Biology*, has a plastic ring binding and pages printed only on the right-hand side, although the quality of the paper is hardly adequate for drawings. Instructions are clear. Many outline drawings to be labeled are included. The introductory part deals with the structure and division of cells; the second part is a very extensive survey of the animal kingdom; the third, a shorter part devoted to representative plants; the last, a section of exercises on heredity, development, ecology, general physiology, applied biology, conservation, primitive man, and bird identification. The emphasis tends to be rather heavily morphological.

ECOLOGY

THE AQUATIC AND MARSH VEGETATION OF MINNESOTA AND ITS VALUE TO WATERFOWL. *Minnesota Department of Conservation, Technical Bulletin No. 3.*

By John B. Moyle and Neil Hotchkiss. Minnesota Department of Conservation, St. Paul. Paper. 122 pp. 1945.

This bulletin is essentially a check-list and key to the commoner aquatic plants of Minnesota. In addition, there is some information on the relative importance of these plants to the waterfowl of the state. Such information is most necessary, as Minnesota, with its large area of inland lakes, supports a large breeding population of ducks. There are brief notes on the origins of these lakes, their classification into three main chemical types, the bottom soils, water levels, and the presence of carp, all of these topics bearing on the distribution and abundance of the vegetation. There are also useful data on the management and propagation of the more important aquatic plants. All this information, together with a bibliography and numerous illustrations of the plants, provides a neat and useful summary and guide for wildfowl managers of the region.

HENRI C. SEIBERT

VERNAL DISTRIBUTION OF MARINE PLANKTON DIATOMS OFFSHORE IN SOUTHERN CALIFORNIA IN 1940. *Bulletin of the Scripps Institution of Oceanography of the University of California, La Jolla, California, Volume 5, Number 4.*

By W. E. Allen. University of California Press, Berkeley and Los Angeles. 35 cents (paper). Pp. 335–370. 1945.

STUDIES ON THE MITCHELL GRASS ASSOCIATION IN SOUTH-WESTERN QUEENSLAND. *2. The Effect of Grazing on the Mitchell Grass Pasture. Council for Scientific and Industrial Research Bulletin Number 185.*

By R. Roe and G. H. Allen. Council for Scientific and Industrial Research, Melbourne. Free. 27 pp. 1945.

EVOLUTION

GEOLOGY AND PALEONTOLOGY OF THE PERMIAN AREA NORTHWEST OF LAS DELICIAS, SOUTHWESTERN COAHUILA, MEXICO. *Geological Society of America Special Papers, Number 52.*

By Robert E. King, Carl O. Dunbar, Preston E. Cloud Jr., and A. K. Miller. Geological Society of America, New York. $2.00 (paper). x + 172 pp.; 45 plates. 1944.

This joint contribution is primarily a work of love by an enthusiastic group of paleontologists and stratigraphers, trained and inspired by the late Charles Schuchert, who also provided the largest share of financial support for the expedition to the central part of Mexico, with a view of working out in some detail the local section of the Permian rocks. The geology has been worked out by King, who also collected most of the studied fossils, the chief objectives being ammonites and brachiopods. Because of their widespread occurrence the local fusulines were also collected, though not systematically; and a few pelecypods, gastropods, crinoids, sponges, calcareous algae, and probably other marine fossils were also collected. Only fusulines, brachipods, and ammonites are described in this paper, by Dunbar, Cloud, and Miller respectively. The chief philosophical achievement of the collective research was the discovery of a few fossils in the limestone claimed to be contemporaneous with the stratigraphically highest (*Cyclolobus*) beds in the Permian of the Salt Range in India. Because the end of the Paleozoic is a particularly intriguing, critical time in the history of organisms, King's belief that more fossils can be obtained from the highest fossiliferous beds is a sufficient incentive for further search in the area. Some new genera and species were obtained besides many others which are identical with those previously described from the contemporaneous Permian rocks of Western Texas and southeastern New Mexico. Dunbar describes a new, very small, degenerate, monotypic fusulinid genus *Rauserella*, and describes three other new and many old species of *Staffella*, *Triticites*, *Parafusulina*, and *Polydiexodina*. Cloud proposes two new brachiopod genera: *Leirhynchoidea* and *Paranorella*, the first with two and the second with one new species, and eight other new species and varieties. The most important paleontologic contribution is by Miller (with the assistance by W. M. Furnish) on the finely preserved cephalopods, chiefly ammonites. It is typical of his numerous contributions to the study of the paleozoic cephalopods of America and the Old World, characterized by thoroughness in the comparison with previously known forms, and by the superb quality of the illustrations. Miller's incessant work on the difficult task of classifying Paleozoic ammonites deserves a special review and appraisal, but here I can only mention the special care he takes in bringing out the essential differences between related genera by illustrating side-by-side their sutures, and also by the study of the ontogeny of these fossils, which he has recently begun. In this he follows the best traditions set by Karpinsky, Gemmellaro, Waagen, Hyatt, Haug, Noetling, Böse, and J. Perrin Smith. Thanks to work by Miller and his pupils and associates, and by F. B. Plummer of Texas, America maintains its traditional lead in the study of the Paleozoic ammonites of the world.

M. K. ELIAS

EVOLUTION AND CLASSIFICATION OF PALEOZOIC CRINOIDS. *Geological Society of America Special Papers, Number 46.*

By Raymond C. Moore and Lowell R. Laudon. Geological Society of America, New York. $1.00 (paper). x + 153 pp.; 14 plates. 1943.

As a rule, paleontologists reserve synthesis and an outline of the evolution of fossils selected for comprehensive research, to the very last stages of their study. Moore and Laudon defy this tradition and herald their conclusions with only a promise "to publish studies dealing with several family groups." They also concede that "others may undertake similar researches directed to determination of the evolutionary trends and zoological relationships of crinoid groups." But in the face of all this future work, they nevertheless "anticipate acceptance" of their classificatory concepts, "as they are found to have sound basis in accurate identification and interpretation of significant evolutionary trends among the crinoids, as they agree with evidence from the standpoint of geologic distribution, and as they reflect phylogenetic development faithfully by expressing true affinity." However, all these self-praising generalities leave the reviewer unimpressed, and wondering why the authors put the cart ahead of the horse, in publishing conclusions with no evidence to back them up. Even the authors themselves feel it necessary to assure the reader that they are not too "brash in undertaking the task of comprehensive revising the classification of Paleozoic crinoids" after only a few years of research, and in boldly disagreeing with the opinions of the masters in fossil crinoid studies: Carpenter, Bather, Wachsmuth and Springer, and Jaekel, who spent their lifetimes on these studies.

The reviewer believes that only the acid test of fundamental investigation will show the validity of the evolutionary generalizations and taxonomic regroupings suggested here. For the present the authors can be credited with an interestingly written critical review of previous researches on paleozoic crinoids, supplemented by good generalized drawings of the fundamental morphologic features on which the revised classification is based. These sketches help one to understand the intricate architecture of crinoid calyces;

also, the meticulously worked out system of indexing the polygonal plates that build them seems useful. But the fossils are not mere geometric objects, and something should be added to so rigidly constructed a morphologic classification of their parts. In vain the biologist will look for references or comparisons with the morphology, anatomy, habit, or life cycles of living crinoids. The fact that crinoid calyx plates and stem joints have distinctive microstructures, by which their true genetic relationship could be tested, is apparently unknown to the authors. Neither do they mention the biologically most interesting symbiotic relationships and pathologic swellings about which much has been written by some of the most profound American and foreign paleontologists. On the other hand, the authors give exhaustive information as to previously and newly established generic and family names, and illustrate them with some selected sketches and photographs.

As to the practical use of crinoids for determining the ages of sedimentary rocks, the information given in this paper is not sufficiently specific: the stratigraphic ranges of the genera are not indicated in relation to the boundaries of lesser than systemic and subsystemic stratigraphic ranks. Neither is there a follow-up here (or even a promise of one to come) to Moore's recent (1939) attempt at an artificial "utilitarian" classification of detached crinoid plates and joints, while all the complicated Latin names devised for them at that time are now declared *nomena nuda*, which of course they are. The fact remains, however, that such parts are common in the rocks, while complete or nearly complete calyces are very rare, and therefore comparatively useless in practical stratigraphic paleontology. A comparatively narrow stratigraphic range for some crinoid joints and plates is now being gradually established (partly by the reviewer), and it is being found that they need not be given cumbersome still-born names, as, with a determined effort, they can be and will be placed within the existing Linnean classification.

M. K. ELIAS

MEET YOUR ANCESTORS. *A Biography of Primitive Man.*

By Roy Chapman Andrews. The Viking Press, New York. $3.00. xii + 259 pp. 1945.

After William Howells' recent book *Mankind So Far*, another popular treatment of the same subject might seem unnecessary; yet Roy Chapman Andrews' personal relation to the explorations in search of the remains of our primitive ancestors makes this a book of real interest. Andrews has drawn liberally from good recent sources to supplement his own first-hand knowledge, and the result is an excellent, breezy account of early man and his anthropoid forebears. A chapter on "The Giants of Java" incorporates Weidenreich's recent studies of *Meganthropus* and *Gigantopithecus*—uncritically, to be sure. The story of Peking Man is especially well told, and the relation of the cave explorations in Spain and southern France makes a story to rival that of Tom Sawyer. There is a chapter on "The First Americans"; and a final speculation on "The Man of the Future," after H. L. Shapiro. There is no discussion of present human races or their origins, but even without that *Meet Your Ancestors* is an entertaining and instructive account of what is probably the most absorbing chapter of biology to most people.

BENTLEY GLASS

SUPRASPECIFIC GROUPS OF THE PELECYPOD FAMILY CORBULIDAE. *Bulletin of the American Museum of Natural History, Volume 86, Article 1.*

By Harold E. Vokes. American Museum of Natural History, New York. 50 cents (paper). Pp. 1–32; 4 plates. 1945.

GENETICS AND CYTOLOGY

PRACTICAL DOG BREEDING.

By Harry C. Peake. The Macmillan Company, New York. $1.95. 142 pp. + 16 plates. 1945.

Written for amateur dog breeders by a breeder of experience, this book includes much practical advice for anyone who has to select and mate dogs, assist at whelping, or care for puppies. Problems of nutrition and training are given attention. A chapter on the genetics and evolution of breeds emphasizes the importance of knowing the Mendelian behavior of the various traits of the dogs being bred, but offers no details. Some interesting explanations of adaptive traits are made. Some of the ideas advanced are unsound, such as the view that "inbreeding intensifies all qualities whether good or bad." The intricacies of inbreeding by fancy methods, "line breeding," etc., seem still to be preferred by dog breeders to more effective methods of selection by means of progeny tests.

On the whole, Peake has prepared a useful handbook which may be of service to biologists working with dogs. There is an index and a selection of fine photographs of champion dogs of various breeds.

BENTLEY GLASS

GENERAL AND SYSTEMATIC BOTANY

AN INTRODUCTION TO THE TAXONOMY AND NOMENCLATURE OF FUNGI.

By G. R. Bisby. The Imperial Mycological Institute, Kew, Surrey. 5s. ($1.25). vii + 117 pp. 1945.

Bisby's little book is aimed primarily at the amateur student of the fungi, i.e., at him "who does taxonomic work for pleasure and does not get a salary for it."

After a brief introduction in which the general problems and principles of the field of mycology are very tersely dealt with, there follows a section on taxonomy. This is prefaced with seven substantial paragraphs of sound practical advice to the prospective amateur, after which there are several pages of discussion on choosing a group of fungi to study. In this section the mode of life, outstanding habitats in which they are found and something of the economic importance of the groups of the true fungi are passed in review for the prospective student. Reference is made in some instances here to important texts helpful to the would-be investigator. Other texts are also mentioned in the following section on equipment, which ends with sound advice to the amateur to join his country's mycological society, where contacts and discussions with other mycologists will greatly stimulate and broaden his interests in fungi.

There then follow two closely allied sections on collecting and examining, and recording. Here, hints on successful methods of bringing from the field adequate amounts of material, well labelled with pertinent data as to host, locality, date, etc., are given. There are also described correct methods of mounting various types of fungi for study. Helpful sections on methods used in measuring significant parts of fungi, methods of obtaining pure cultures, and the maintenance of stock cultures are included. It is to be regretted that these sections are confined entirely to the methods used in the higher, terrestrial fungi. With much simpler or inexpensive equipment than is described, the amateur could also derive considerable pleasure from the study of lower groups, for example, the water fungi.

Sections then follow on the routine procedure to be used in ascertaining the identity of a fungus, whether it be a parasitic form or one of the more difficult to determine saprophytes. There is found in these sections some very sound advice which might well be remembered by the professional as well as the amateur, particularly that explaining the etiquette to be followed in dealing with specialists in various groups. Closing Part I on taxonomy are sections on the correct methods of preserving, storing, labelling, and filing material for use and on preparing and illustrating papers for publication.

Part II is concerned with the aims and methods of nomenclature. After a discussion of the categories of fungi, the intricacies of synonymy are expounded, with specific examples of historic interest cited. The reviewer was greatly pleased to see emphasized in this section that "Misidentifications should not be listed in the synonymy . . . " There then follows a careful exposition of types and the type method that should be read by every student of the fungi, and which closes with this sound doctrine: "Nomenclature must not permit error to prevail—but the Rules suggest that one should make every legitimate effort to keep names stable."

A section on the proper preparation of diagnoses is given. Here, not only are the essential points to be included in the preparation of a description of a new species given, but pitfalls to be avoided by the novice are indicated. With respect to the thorny problem of Latin diagnoses, the author takes a very realistic viewpoint. "In these days, when many mycologists cannot write Latin and can scarcely read it, there is something to be said for the common practice of writing the diagnosis in one's own language, having it put into Latin by someone who knows that language, and publishing both diagnoses."

One of the most useful features of the book is the nearly 50 pages devoted to the International Rules of Botanical Nomenclature. Of great value to the mycologist is the citing throughout of examples taken from fungi rather than from phanerogams. Frequent illuminating comparisons with zoological procedure in nomenclature are also made. In spite of the author's obvious interest in what to many seems "armchair botany," it is quite evident that he holds in low estimation much of the fol-de-la of the nomenclatorial barons, a viewpoint I enthusiastically share. The book closes with a short list of pertinent references and an index.

Although said to be primarily for the guidance of the amateur, this small volume will be of great assistance to both the professional and the industrial mycologist. It is a worthy and welcome addition to the excellent series of publications from the Imperial Mycological Institute.

F. K. SPARROW

HOW TO KNOW THE MOSSES. *Pictured-Keys for determining many of the North American Mosses and Liverworts, with suggestions and aids for their study.* (*Pictured-Key Nature Series*).

By Henry S. Conard. William C. Brown Company, Dubuque, Iowa. $2.50 (cloth); $1.50 (spiral). 166 pp. 1944.

Henry S. Conard of Grinnell College, President of the Sullivant Moss Society, is the author of this useful and popularly written book on the identification of common mosses and liverworts. It is profusely illustrated with small line drawings which are sufficiently clear to be entirely usable. The first 23 pages are devoted to introductory notes in which mosses are defined in terms of "what they are not" as well as in terms of "what they are." There is a precise description of the life history of a moss, some notes on what kind of habitat mosses grow in, a statement on the limited uses to which they are put, and some preliminary aids

for classification. There is also a chapter on how to study mosses, with suggestions about equipment and methods of collection and preservation. A little section on "What to look for" in the structure of mosses and liverworts will be particularly useful for beginners. There is also a short, but well selected and well annotated list of standard reference books on the subject.

The main part of the book, approximately 110 pages, is given to illustrated keys for the identification of mosses and liverworts. There are drawings of approximately 275 species. The key is artificial in large measure, but at the end of it there is a systematic list of the species arranged by families and genera. An index and glossary at the end are again profusely illustrated with drawings.

The book should be stimulating and useful for the encouragement of those who find amusement and intellectual satisfaction in delving into the intricate mysteries of the lower plants. With it one should be able, even working alone and without a reference collection, to learn the names and forms of most of the commoner mosses and liverworts. Incidentally, the methods which Conard uses to prepare the student for using the key could profitably be studied by those who write keys and manuals to the flowering plants.

H. M. RAUP

BRAZIL. *Orchid of the Tropics (Air Gardens of Brazil). By Mulford B. Foster and Racine Sarasy Foster. The Jaques Cattell Press, Lancaster.* $3.50. xi + 314 pp.; 72 plates. 1945.

"Brazil. Orchid of the Tropics," describes two botanical collecting journeys made in 1939 and 1940. The text is arranged in such a way as to make it impossible to say which of the authors is responsible for any particular part. In describing their experiences they consistently use the pronoun "we," but the exploits and experiences of each as an individual are told in the third person. The book consists of 47 chapters and is profusely illustrated with halftone photographs, four of which are in color. There are also many pen drawings by Mulford Foster.

In the season of 1939 the Fosters first spent some time in the vicinity of Rio de Janeiro and São Paulo. They then went to Bahia by steamer and from there made several collecting excursions—one to Ilhéos by sea, and one by rail to Jacobina in the interior of the state of Bahia. Back at Rio, they visited Mt. Itatiaya, and then went into the state of Esperito Santo for further collecting. From Rio again they traveled into the states of São Paulo and Paraná by automobile.

The expedition of 1940 was divided principally between the states of Minas Geraes and Matto Grosso. In the former the collection localities were Bello Horizonte, Serra do Cipó, Caraça, and Parque Aymorés. In Matto Grosso they went west to Corumbá by rail, collecting at various localities on the return journey. While in the vicinity of Rio they visited the Organ Mountains.

Apparently the initial interests which took the Fosters to Brazil were not purely botanical. They have a garden in Florida and have for some years been developing the use of tropical plants in landscape architecture. An artistic interest in plants, particularly for their use in design, permeates all of the authors' discussion of Brazilian floras and landscapes. Their initial tools were, therefore, the camera, pencil, and a digging instrument. The last was important, because they wished to bring living plants back to their Florida garden.

For some reason they had become particularly interested in two families of plants—the Bromeliaceae or Pineapple family, and the Orchidaceae. Fortunately for botanical science, they had corresponded with Lyman B. Smith of the Gray Herbarium, who is a world authority on the Bromeliaceae. Also they somehow realized that they must return with material proof of their observations. Their description of their realization of the significance of botanical specimens should be read by all would-be field naturalists. They were unfortunate in that they had to go through the trials and tribulations of the beginning collector while trying to make specimens of such stubborn and "unpressable" plants as occur among the Bromeliads. They are to be congratulated and highly commended for having seen the problem through, and for having made a fine contribution. Their collections have greatly extended the world's knowledge of Brazilian bromeliads and orchids.

The book as a literary product is a curious mixture of fine writing and flagrant, though often amusing, misuse of certain English forms. This can be illustrated best by a few quotations. "Going up from Santos by train one is carried over one of the world's astounding engineering feats in a cable railway" (p. 171). In a good account of the Carnauba wax palm, we are told that: "For centuries this palm has been called the most completely useful plant known to man because of its innumerable uses." "As a food, it supplies almost a balanced diet, for the native cooks the roots, roasts the seeds, making a starch like sago which is a staple of their diet, and he stews up the leaves for a leaf-green. By further processes of various parts the native finds a medicine." (pp. 268–269). On page 281 there is a lovely account of a huge blue butterfly which hovered about while the party was at lunch one day. The butterfly shared the center of attraction with a blonde Capuchin monkey, which also came quite close. At the end of a fine paragraph we read: "Its friendly presence had been reassuring and our trip to Urucúm will always be remembered by big blue butterflies and—a blonde monkey."

These things are almost side by side with such fine descriptions as the one of the process used by the natives in cleaning cacao beans:

It was a bright clear morning when we watched the men do this dance on the cacao beans. Rhythmically, to an undertone chant they stamp round and round on the pile, breaking it down gradually, collecting on feet and ankles the red-brown juice created by the frequent sprinkling of water which helps loosen the grey brown dust from each bean. Round and round again these barefooted brown-skinned natives circle the hill of beans, as their monotonous singing chant encourages the pulsing rhythm of vigorous stomping feet. The voices in unison hold them together in spirit and rhythm, helping them feel the surge of their forebears' blood course through their black veins. The chant or the rhythm was not monotonous to them, it was insistent repetitions, demanding fulfillment, exemplifying the simple repetitions of life. The work no longer is drudgery, it is forgotten; work has become exalted in the captivating rhythm. They are working as one, the effort of the individual laborer is submerged and a unified work has become an expression of happiness in the dance and song. They are typical of all primitives who sing away their cares, who soften the burden of toil in the touches of music's soul. Primitives working with that which gives them food and clothing take their pleasure as they work.

Brown bodies swaying, bending, pushing, straining—beans, feet, toes, extended muscles all the same chocolate color—all synchronized to make one great pulse with yet an under pulse, a syncopated beat flashed by a quick extra twist of the ankle, gave this dance that completely primitive rhythm out of predated history where the complicated underbeats of the dance originated. That quick twist and pivoting on the heel for only a tiny fraction of a second was fascinating to behold in its flashing competence.

There is another of these gems on pages 207 and 208:

Not one of the plants on this great mountain slope would you find growing on our side of the equator; not one of them in our gardens or botanical collections. All these low-growing, spreading, rugged, yet delicately formed plants bore the most gorgeous and vivid colors from white and all the primary colors and their hues to the grays and purple-black. There were miniature sprawling, blue, spruce like plants which actually were cousins to our lowly dandelion; deep orange clusters held lighter orange flowers, the same family as our snapdragon; deep purple flowers encased in thick, grey-green leaves, was another mint; beds of spiny-leaved rosettes holding orange-red spikes, *Dyckias*, by name, yet cousins of our Southern "Spanish Moss"; and a lovely blue gentian seemed so out of place growing in this dry parched area. These and many more were the surprises that greeted us as we botanized among new acquaintances who were relatives of old friends, friends that have blossomed in our lives since childhood and filled many hours with their company. Surely there is no spot on this earth which is lonely if a flower blooms there.

The book will distress some of those biologists who are rigorous in their interpretation of supposed adaptive structures. It is filled with teleological explanations of the habits and forms of plants. However, I find it difficult to condemn it on this account, for the authors' interest in the intricate problem of adaptation is so obviously sympathetic and genuine.

I find myself wondering what I should have done if I had been an editor and this book had come to my desk. I think I would have printed it approximately in the form in which it now appears. To have altered it in such a way as to iron out its irregularities in composition and ideology would have required such revolutionary changes that the book almost certainly would have lost the precious spark that flashes on so many of its pages.

H. M. RAUP

ECONOMIC BOTANY

YOUR FORESTS.

By Martha Bensley Bruere. Foreword by Gifford Pinchot. J. B. Lippincott Company, Philadelphia. $2.50. x + 156 pp.; 32 plates. 1945.

A fascinating and timely but non-technical presentation of a subject of the utmost importance to the American public, by an author who is—by virtue of experience and distinctive abilities—eminently qualified to make such a subject interesting to the layman as well as to the specialist.

In story form, such topics as the kinds and distribution of our forests, and their care, protection, and development, both under government and private control, are dealt with; and exciting new features include—information about many new uses and treatments of wood, e.g., in plastics, also accounts of foresters and their varied duties. Fifty-six fine photographs, carefully selected to interpret the text, and an end-paper map, showing the location of United States and Canadian forest regions, constitute further valuable contributions.

Not only is this a valuable "career-book" for young people, particularly boys, but it is also an excellent reference work of a non-technical nature for college courses either in general biology or botany.

LADEMA M. LANGDON

TREES, SHRUBS, AND VINES FOR THE NORTHEASTERN UNITED STATES.

By George Graves. Oxford University Press, New York, London, and Toronto. $3.00. xi + 267 pp. 1945.

Trees, Shrubs, and Vines for the Northeastern United States is a handy, pocket-sized list of woody species that are desirable for ornamental plantings in this region. Approximately 650 species are included. Both Latin and English names are given for each, along with precise notes on its habit of growth, flower-

ng time, methods of propagation, and outstanding qualities for various ornamental purposes. The book is illustrated with 68 halftone plates which are well chosen and adequately reproduced. The list is arranged alphabetically, and the technical names are those in Rehder's *Manual of Cultivated Trees and Shrubs*. Some useful classified lists are given at the end of the book: Deciduous Trees; Evergreen Trees; Woody Plants of Shrub-like Habit; Climbing and Clambering Vines; Woody Plants for Groundcover, Banks, and Underplantings; and Woody Plants for Rock Gardens. There are also chapters on "How to Shop for Trees, Shrubs, and Vines," and "The Problem of Pruning."

The success of any book such as this depends in large measure upon the perspicacity of the author in selecting, out of the thousands that are available, the most desirable and useful kinds of plants. In his introduction Graves has stated this problem quite clearly:

> There are now some seven or eight thousand trees, shrubs, and vines available for planting in northeastern North America. Of this varied assemblage, many are unworthy or unnecessary for use in gardens, parks, or roadside development.
>
> In order to make up any manageable selective list, it is necessary to consider a number of factors. Geography as it relates to climate, soil types, and native background must guide the selection of plant materials for different areas. The diversified types of planting call for suitable materials. The attitudes and preferences of individual gardeners have much to do with the popularity of certain plants or groups of plants.

The author has had three main objectives in making the selections for the present volume: "The first was the evaluation of those species and garden varieties that have been finding their way into the development of home grounds and other similar intimate areas . . ." "The second objective has been to consider woody plant materials suitable for the development of broader, wilder roadside areas in keeping with the physiognomy of the native landscape." The third objective has been "the selection of woody plants of small stature adaptable for use in rock gardens and similar limited areas."

Graves has apparently done an excellent service in preparing this little book. It should prove exceedingly useful for those who need practical advice in their choice of plant materials for landscaping.

H. M. RAUP

THE SPICE HANDBOOK. *Spices, Aromatic Seeds and Herbs.*

By J. W. Parry. Chemical Publishing Company, Brooklyn. $6.50. xvii + 254 pp. 1945.

Although spices are extremely important and useful commodities, the average person knows little about them. Comparatively few reference books are available and these are not up to date. The present handbook was prepared primarily to meet the requirements of the spice trade by furnishing definite and concise information about the products with which it deals.

Some fifty of these products are discussed under the categories of spices, aromatic seeds and herbs, the latter group including various miscellaneous flavoring materials. In each individual case, information is given regarding the origin, distribution, physical properties (color, size, appearance, aroma, and taste), uses, adulteration, grinding, and packing, together with pertinent data in regard to the starches present, the essential oils, and government standards.

Formulae for various spice mixtures are included, as well as excerpts from the Pure Food Laws of the United States and Canada. An appendix contains the various types of standard contracts and a table of distances and hours from the exporting and processing centers to the ports of the United States and Canada.

Since this handbook is designed for the spice trade and not for botanists or the general public, there are naturally quite a few omissions. No reference is made to the interesting history of spices or to their cultivation. Neither are there any extensive botanical descriptions of the species concerned. By and large, however, the orderly method of presentation, the essential data, and the excellent illustrations make this work a valuable addition to any library of economic botany.

ALBERT F. HILL

HORTICULTURE AND HORTICULTURISTS IN EARLY TEXAS.

By Samuel Wood Geiser. Southern Methodist University, University Press in Dallas. $1.50 (cloth); $1.00 (paper). 100 pp. 1945.

This little book is an attempt to present in broad outlines the history of horticulture and horticulturists in early Texas. Admittedly only a preliminary study, it is the author's hope that it will serve as a basis for a fuller and more adequate account at some later time.

In Part I, which deals with horticulture, the material is organized under the following headings: Fruit Culture in Early Texas (1820–1850); Census Returns for Fruit Crops in Texas (1850–1930); Wild Fruits in Early Texas; Early Texas Horticultural Societies (1870–1896); Some Texas Horticultural Journals (1868–1907); Bibliography.

Part II comprises short biographical sketches of 165 horticulturists who were active in the State from 1838–1910. An index of the horticultural varieties originated and introduced in Texas is appended.

ALBERT F. HILL

THE MANAGEMENT OF YOUNG VOLUNTEER HARDWOOD STANDS. *The Black Rock Forest Bulletin No. 13. By Henry H. Tryon. The Black Rock Forest, Cornwall-on-the Hudson, New York.* $1.00 (paper). 28 pp.; 1 picture. 1945.

GENERAL AND SYSTEMATIC ZOOLOGY

PROTOZOOLOGY. *Third Edition.*

By Richard R. Kudo. Charles C. Thomas, Springfield, Illinois. $8.00. xiii + 778 pp. 1946.

The third edition of Kudo's *Protozoology* follows in most respects the general plan of the second. However, chapters have been added on "Major groups and phylogeny of Protozoa" and "Collection, cultivation, and observation of Protozoa." In addition there has been considerable revision of some of the chapters with the addition of much of the more recent work.

As in the previous editions, the major part of the book is devoted to a survey, mainly taxonomic and morphological, of most of the genera and many of the species of the protozoa. The section on "General Biology" is considerably shorter and not as well worked out. There are several rather important omissions. For example, in discussing cytoplasmic inclusions, no mention is made of the critical article on this subject by MacLennon in *Protozoa in Biological Research*. As a matter of fact, this valuable book is hardly mentioned in the text, although it is included in several of the chapter lists of references. The section on general biology is on the whole more of a compilation of facts than an analytical review. For example, while the chapter on physiology describes a large number of phenomena, little is said about the mechanisms involved. It is true that our knowledge of these is still woefully inadequate, but the chapter's value could be greatly increased by an attempt to bring together what is known. As an instance, the section on irritability lists a number of examples of reactions to stimuli. Yet practically nothing is said of the mechanisms involved, although a good deal is known from the work of Jennings, Mast, and others.

The reviewer does not wish to appear unduly critical, since throughout the book there are many excellent sections, and the shortcomings are perhaps inevitable in any work which reviews the whole biology of a major group. Like the previous editions, it should prove an invaluable summary of our knowledge, both for the student beginning the study of the protozoa and for the mature investigator. It is well and profusely illustrated and has not suffered from wartime shortages as have so many recently published books.

R. F. KIMBALL

GONIOBASIS LIVESCENS OF MICHIGAN. *Miscellaneous Publications, Museum of Zoology, University of Michigan, Number 64.*

By Calvin Goodrich. University of Michigan Press, Ann Arbor. 35 cents (paper). 36 pp. + 1 plate. 1945.

This study of the second most widely distributed aquatic snail in Michigan considers its distribution, proportions, variations, morphology, ecology, and taxonomy.

KEYS TO THE ANOPHELINE MOSQUITOES OF THE WORLD *With Notes on their Identification, Distribution, Biology, and Relation to Malaria.*

By Paul F. Russell, Lloyd E. Rozeboom and Alan Stone. The American Entomological Society, The Academy of Natural Sciences, Philadelphia. $2.00 (paper). 152 pp. 1943.

The title indicates the scope of this work. It was prepared for the Preventive Medicine Division of the United States Army and proved of great value to Medical Officers and Entomologists engaged in anti-malaria work during the war.

There is a brief introduction giving the main features of the structure of adult and larval anopheline mosquitoes, with illustrations. This is followed by eight chapters, each dealing with the anopheline mosquitoes of particular regions, covering virtually the entire earth. Each chapter includes keys to the adult females and the fourth instar larvae. These are followed by notes on each species, giving the original citation, the type locality, habitat of the larva, habits of the adult (where known), and the known relation to the transmission of malaria.

Chapter XI lists the important vectors of malaria of the various regions dealt with in the text. There is a good list of references and an index. This work is of great value to any student of the anopheline mosquitoes. The keys dealing with the anophelines of the Australian and Asiatic regions are now out of date, but the other parts are as valuable as ever.

ROBERT MATHESON

THE MOSQUITO ATLAS. *Part I. The Nearctic Anopheles, Important Malaria Vectors of the Americas, and Aedes aegypti, Culex quinquefasciatus. Part II. Eighteen Old World Anophelines Important to Malaria.*

By Edward S. Ross and H. Radclyffe Roberts. The American Entomological Society, Academy of Natural Sciences, Philadelphia. 60 cents each (paper). (I) iv + 44 pp.; (II) iv + 44 pp. 1943.

These two publications consist of illustrations of the larvae and adults (especially of the male genitalia) of certain species of mosquitoes, along with diagnostic

descriptive details. Part I deals with the Nearctic *Anopheles* and *Aedes aegypti* and *Culex quinquefasciatus*. Part II illustrates the details of 18 Old World anophelines important to malaria. The illustrations are beautifully done and should be of great help in the identification of the species. Notes on the distribution and habits and habitats are also given.

ROBERT MATHESON

THE NEARCTIC SPECIES OF TENDIPEDINI. [*Diptera, Tendipedidae (=Chironomidae)*]. *The American Midland Naturalist, Volume 34, Number 1.*

By Henry K. Townes, Jr. The University Press, Notre Dame. $1.00 (paper). 206 pp. 1945.

The author states: "This paper contains a taxonomic treatment of the adult midges belonging to the tribe Tendipedini of the family Tendipedidae (= Chironomidae) occurring in the United States, Canada, Alaska, and Greenland. These species have formerly been included in the genera *Chironomus, Pseudochironomus, Pentapedilum,* and a few sometimes in *Tanytarsus.*" The classification is based on that of Goetghebuer in E. Lindner's *Die Fliegen der Palaearktischen Region,* parts 107 and 109 (1937). Though the author states the classification he uses is based to a large extent upon the characters of the immature stages, yet he gives no discussion of these stages, nor does he indicate the basic characters on which his classification rests.

In the tribe Tendipedini the author recognizes 15 genera (2 of which are here proposed as new) and a number of subgenera (several of which are proposed as new). In all, 201 species are described, of which 104 are proposed as new species. Adequate keys are given to the subfamilies, to the Nearctic genera of Tendipedini, and to the species of the various genera. The male genitalia of most of the species are figured, and the structure of this organ is used extensively in the keys. Very little biological information is included.

In this work the names proposed by Meigen (1800) are accepted and not those of Meigen (1803). This involves a considerable change in the nomenclature used by most American workers up to the present time. The author's hope that this may bring about some stability in nomenclatural problems is rather optimistic. However, we have here a synoptic review of this tribe of midges which should form a basis for future work and should be of great value to all those engaged in limnological and fisheries work; it would have been much more valuable if the immature stages could also have been included.

ROBERT MATHESON

THE NORTH AND SOUTH AMERICAN ASCIDIANS. *Bulletin of the American Museum of Natural History, Volume 84.*

By Willard G. Van Name. American Museum of Natural History, New York. $8.00 (paper). viii + 476 pp.; 31 plates. 1945.

This is a scholarly, long awaited and much needed work. The author, the leading ascidian systematist of this hemisphere, has at various times published regional accounts of the ascidian fauna, especially of the eastern seaboard of North and Central America. Now these have been brought together and incorporated with accounts from northern and western coasts of North America and all records of South American forms as far as Antarctic waters. Many of the original descriptions of west coast species have obviously been amplified by personal acquaintance not previously indicated. Included are the faunas of Greenland and the Aleutian chain, the West Indies and Bermuda, and to the south the Falklands and South Georgia.

The monograph is admirably organized and very well illustrated with text figures. The plates are helpful, though it is a pity that the difficulties of obtaining photographs of ascidians in a living condition are so great, for ascidians, compound ones especially, become degraded more than most organisms as the result of preservation, and nothing of the natural beauty that so many possess is discernible. There is a short but eminently clear general introduction, perfectly adequate for its purpose, though considering the authority and experience of the author a much more elaborate statement of opinions would have been welcome. The coverage is as complete systematically as it is geographically, all ascidian families being represented by the 73 genera and 309 species included. Each species is described meticulously, its geographical range, both horizontal and vertical, is indicated, and a list of synonyms and references is included together with a critical and judicious appraisal of all earlier accounts. Each has clearly been given full weight of consideration, and the summing up comes at a time when, as the author himself says, most of the existing species of ascidians in the hemisphere have now been recorded, and future additions will be very gradual. A 14-page systematic index and a 16-page bibliography make the somewhat massive contents readily usable, and the monograph should be accessible not only to anyone with an interest in ascidians but to all persons in anyway concerned with marine ecology. While the scope is ostensibly limited to Western Hemisphere species, so many of these have a transoceanic or circumpolar distribution that the value of this work is universal.

N. J. BERRILL

EXOTIC AQUARIUM FISHES. *A Work of General Reference. Sixth Edition.*

By William T. Innes. Innes Publishing Company, Philadelphia. $5.00. 507 pp.; frontispiece. 1945.

This stand-by of aquarium owners grows steadily bigger and better. The present edition is a beautiful book—paper, type, half-tones, color pictures, endpapers (world maps of fish distribution), and binding leave no room for criticism. The author's portrait, now added, reveals a man who, as an amateur, has made a worthy contribution to our literature on fishes.

The first 100 pages deal with the principles of aquarium management: oxygen, light, temperature, feeding requirements; fish foods; enemies; diseases; general management; plants and planting; the classification of fishes; and spawning. These are the fruit of a lifetime of experience. There then follow 360 pages of descriptions of individual species, varieties and hybrids, arranged by families, and checked as to classification by George S. Myers, who also prepared the 7 maps of family distributions. In general, each page carries a photographic illustration with a description below. These hundreds of fine illustrations, of which 63 are in superb color, are the work of the author. Wherever a fish exhibits features of exceptional interest, the descriptive notes are longer, and may extend to a number of pages, with additional illustrations. At the end of the book are discussions of sex changes in fishes, marine aquariums, wholesale breeding, collecting and transporting fishes, aquarium construction, miscellaneous information, and, of course, indexes of both general subjects and of the fishes themselves. No effort seems to have been spared to make this handbook a naturalist's dream. It is a grateful surprise that its price can remain relatively so low.

BENTLEY GLASS

PHYLOGENETIC POSITION OF THE CITHARIDAE, A FAMILY OF FLATFISHES. *Miscellaneous Publications, Museum of Zoology, University of Michigan, Number 63. By Carl L. Hubbs. University of Michigan Press, Ann Arbor.* 35 cents (paper). 38 pp. 1945.

Five monotypic genera (*Citharus, Citharoides, Paracitharus, Brachypleura, Lepidoblepharon*) are here reclassified as a distinct primitive family, on the basis of the possession of a pelvic spine and free gill membranes in all genera, and of vomerine teeth and a supplementary maxillary in some. Related to the flounders, the family is divided into two subfamilies (eyes on the left; eyes on the right), making a third independent origin of sinistrality and dextrality in flatfishes. The characters of this family strengthen the view of the monophyletic origin of all the asymmetrical fishes (Heterosomata). Convergent evolution has been common in the family. The paper is without illustrations.

REPTILES OF THE PACIFIC WORLD. *The Pacific World Series. By Arthur Loveridge. The Macmillan Company, New York.* $3.00. xii + 259 pp.; 1 map. 1945.

The American Committee for International Wild Life Protection is sponsoring a series of books under the general title of "The Pacific World Series." The mammals, insects, native peoples, plants, fishes, and shells have been treated; the present volume is concerned with the reptiles and amphibians. A special paper-covered edition, designed to sell for twenty-five cents, was prepared for the benefit of service men in the Pacific. The author is well qualified; he has seen foreign service (with British forces in Africa during the first World War); he is an enthusiastic herpetologist; and he writes lucidly and interestingly.

Following a "Foreword" by Fairfield Osborn, the book opens with two short introductory chapters and continues with separate chapters on the turtles, crocodilians, lizards, non-poisonous snakes, elapids, seasnakes, and vipers. Fully one-quarter of these chapters are taken up by semi-technical keys, sometimes to genus (e. g., boa's), sometimes to species and race (e. g., terrapins), and sometimes there are no keys at all (e. g., colubrid snakes). The concluding chapters of the volume include information on snake-bite treatment, Pacific amphibians, and methods for collecting and shipping specimens. Appended are a two-page chart showing the distribution of reptiles and amphibians (by family) among the island groups of the Pacific, an annotated bibliography of nineteen items, and a species index arranged in systematic order.

The jacket of the book is enlivened by the New York Zoological Society's striking photograph of a Komodo Monitor, and the endpaper carries an outline map of the East Indies and the Pacific Islands. Some seventy line drawings (about ten to a page), prepared by Eugene N. Fischer, are included. Their main function is to illustrate points in the keys that require clarification.

It is extremely difficult to evaluate this volume properly, for herpetology has little else that is quite comparable. It contains a great deal of interest to specialists in the field who are not particularly conversant with the Pacific fauna; but this is not the audience for which the book was designed.

Service men with no zoological training but with developing curiosities about the strange animals around them must have found the book very stimulating, especially if they were able to associate correctly pertinent sections of the text with the reptiles and amphibians that came to their attention. Unfortunately, many must have found this a difficult task for a variety of reasons: (1) for many groups there are no identification keys, e. g., the 300-odd species of the colubrid snakes; (2) many of the keys are long and difficult to use, despite the sincere, and highly successful, attempts to simplify terminology; (3) for the sake of reasonable brevity, many species have not been discussed; and (4) there are no photographs of even the most conspicuous members of the herpetofauna. Ex-

tenuating circumstances were certainly involved. To be of the greatest potential value the book had to be organized within the shortest time possible; it had to cover a wide territory; and it had to be encyclopedic in content but not in size. Furthermore, the richness of the Pacific herpetofauna and the uneven and scattered condition of its literature were scarcely the materials from which a series of simple and definitive identification keys could have been constructed. Under the circumstances Loveridge did a good job; had the conditions been otherwise he could have done a better one.

A few specific remarks may be appended. The map is inadequate; it does not show the islands east of the Society group nor does it locate some of the islands mentioned in the text, e. g., Sakhalin, the Moluccas, Bismarcks, Bonins, and Timor. The account of the elapids would have been more interesting had there been included material from Bogert's recent work which demonstrated the dentitional basis for the difference between the habits of the spitting and biting cobras. There is an error in the key to the snake families (p. 106) which would prevent the correct identification of the snakes of the Xenopeltidae. Exception should be taken to the statements suggesting the use of potassium permanganate in snake-bite treatment.

ARNOLD B. GROBMAN

THE BIRDS OF NORTHERN THAILAND. *Smithsonian Institution, United States National Museum Bulletin 186.*

By H. G. Deignan. United States Government Printing Office, Washington. $1.25 (paper). v + 616 pp.; 9 plates. 1945.

In this publication, northern Thailand is taken to consist of all pre-war Thailand north of 17° 47′ N., between the Salwin and the Mae Khong rivers. The geography and climate of this area result in three zoogeographical areas, the northern, western, and eastern divisions. The northern division not only has a northern element of birds, but also some southern forms which have travelled in the valley of the Mae Khong; the western division has a characteristically Indo-Burmese fauna; while the eastern has a characteristically Indo-Chinese fauna. These differences are not discussed in any detail.

The annotated list is a compilation of records obtained by other explorers and collectors, as well as those from Deignan's own work in that area. Under each species appear data on habits and behavior as well as the description of plumage. This work is a valuable contribution to an only recently investigated region of the world.

HENRI C. SEIBERT

WHAT BIRD IS IT?

By Anna Pistorius. Wilcox & Follett Company, Chicago. $1.00. 24 pp. 1945.

Here is a good book for the young child with an awakening interest in birds. Twenty-three common American birds are illustrated in color with accompanying notes on habits, but without identification. At the end there is a key supplying this; so it is clear that the title of the book is appropriate. The pictures are good, except that the color values are sometimes off—the mockingbird is quite blue, for instance. The notes are short and interestingly written.

GETTING TO KNOW THE BIRDS.

By C. S. Bayne. Illustrated by Ralston Gudgeon. William Collins Sons and Company, London and Glasgow. $2.50. 102 pp. 1944.

The nineteen full-page portraits of English birds in this book are undoubtedly among the finest bird paintings ever made. They combine the beauty of realistic artistry with a grace and balance of design that remind one of the delicacy of Japanese and Chinese art. The colors are of blended tones that make most bird pictures look by contrast altogether garish and unnatural. The numerous little pencil sketches are equally fine. Since the birds illustrated include such familiar names as the English robin, tit, blackbird, starling, chaffinch, wren, swallow, cuckoo, wagtail, kingfisher, skylark, reed bunting, and redstart, even Americans who have never seen them will be interested in their appearance.

The short and simple anecdotes by Bayne, that tell how he got to know these birds about his home, make a fitting accompaniment to the pictures. All in all, here is a book to treasure!

BENTLEY GLASS

INTERESTING BIRDS OF OUR COUNTRY.

By S. Kip Farrington, Jr. Illustrated by Lynn Bogue Hunt. Garden City Publishing Company, Garden City, New York. $1.50. 27 pp. 1945.

This collection of bird pictures and notes includes 88 of the most common or most interesting American birds. The brief descriptive notes are in most cases good, although in some instances the destructiveness of birds that are more beneficial than not is unduly emphasized. The colored illustrations seem to emphasize brilliancy of background more than fidelity in depicting the birds themselves. The red-headed cowbird, for example, is a strange phenomenon. Most of the birds, however, are sufficiently recognizable for a beginner. At the end there is a double-page devoted to methods of bird study, feeding, and the construction of bird houses.

CHECK-LIST OF BIRDS OF THE WORLD. *Volume V. By James Lee Peters. Harvard University Press, Cambridge.* $5.00. xi + 306 pp. 1945.

Peters' monumental compilation of the birds of the world has now attained five volumes. This most recent member of the series includes the hummingbirds, colies, trogons, kingfishers, todies, motmots, bee-eaters, rollers, hoopoes, and hornbills. The large family of the hummingbirds contains over half of the birds listed. It is also one of the most difficult and complex groups of birds for the taxonomist to work with, and Peters freely admits that much more information is needed before any adequate settlement of the problems can be made. In several instances only one specimen has ever been collected, and hybrids are notoriously frequent. It is believed that if less attention were to be paid to the elaborate adornments of the males and more to the females, a better understanding of the hummer's relationships might be reached. Peters' conservatism and his adherence to the International Code of Nomenclature makes his treatment preferable to the latest one available, that of Simon in his *Histoire Naturelle des Trochilidae.* As usual, there are copious footnotes and a complete index. The type has not been changed, although the paper is inferior to that of previous volumes. The author still has a great task to complete, and it is to be hoped that future volumes can appear at more frequent intervals.

HENRI C. SEIBERT

HOW TO LOOK AT BIRDS. *The Theory, Practice and Gospel of Bird Watching.*

By T. L. Bartlett. Illustrations by Roland Green. Royal Society for the Protection of Birds, London. 2s. (paper). 20 pp. No date.

Emphasis is placed in this little pamphlet on the living bird and how to identify species by characteristic traits of flight, song, and habit. Chapter One is entitled "The Theory of Bird Watching." After reading it the reviewer admits to a certain degree of bewilderment as to what this theory may be. Brief paragraphs jump from the balance of nature to the feathered wing, and thence to the relationship between bird and man and birds and aeroplanes. Statements like: "If there were no birds to keep check on insects they would multiply so fast that in seven years they would eat up all the green vegetable matter on the earth" belong in the raised eyebrow department.

Chapter Two points out that size, shape, posture, flight, color, song, habits, and habitat should be learned for identification. Although proper advice to study common and local birds is given, no concrete methods of study, such as use of field glasses, bands, blinds, etc., are even mentioned. Chapter Three, "The Gospel of Bird Watching" can be classified with Chapter One. There are numerous pen and ink sketches.

HENRI C. SEIBERT

THE PRINCIPLES OF CLASSIFICATION AND A CLASSIFICATION OF MAMMALS. *Bulletin of the American Museum of Natural History, Volume 85.*

By George Gaylord Simpson. American Museum of Natural History, New York. $3.50 (paper). xvi + 350 pp. 1945.

Taxonomy, as we know it, had its formal origin in the hands of Linnaeus almost two hundred years ago, and his concept of binomial nomenclature as a practical means of labeling groups of animals and plants, so that they might be distinguished conveniently from one another, has remained the basis of systematics to the present day. Inherent also in the Linnaean system of cataloging animals has been an attempt to recognize the relationships and affinities of the creatures involved. The growth in taxonomy, from its rather simple beginning in 1758, has been rapid, and has been marked by a tendency toward restriction, both in method and approach.

The increasing complexity of the problem made necessary the formulation of rules to govern the use of terminology. The so-called international rules of taxonomic procedure have given a remarkable measure of order and stability to this science. This necessarily rigid definition of method unfortunately has been accompanied by a severe restriction in the diagnosis of taxonomic units. Because of the mass of material to be studied and classified, systematists have utilized only a few parts of the animal in arriving at their conclusions. Thus teeth in mammals and the genitalia in insects have been chosen, presumably because they are more "reliable" than other structures. Whether this is true is a matter of opinion, but even if admitted, such an attitude has removed taxonomy as a challenging and dynamic field of biological endeavor. Its recent renaissance has been accomplished by those who have the broader point of view of the older naturalists, and who have related classification to biology as a whole.

It is with a discussion of these two factors that the author has introduced his recent classification of the Mammalia. With admirable clarity he has set forth the modern concept of the method and the factual basis of taxonomy, and these closely written pages should be carefully read and digested by every incipient systematist, if not every zoologist. Simpson has discussed the application of genetics and morphology to phylogeny, and in turn of the data of phylogeny to classification. Likewise he has pointed out the dimensions of taxonomy in relation to its units of genus and species, and the significance of horizontal and vertical

classifications. Into this broad theoretical fabric the author has woven the details and rules of taxonomic procedure with such succinctness that there will be little excuse for incompetence and amateurism among future systematists.

He has pointed briefly to the trends of taxonomy in the last generation. The once static science found itself squarely in the midst of the actively growing biological attack on the species problem. The more discerning systematists saw in their science an approach, supplementary to genetics and ecology, to the definition of the species. The realization of his true position in modern biology is certainly of importance to the taxonomist, but it should be asked (as Simpson does) whether this evolution in point of view is fundamentally a theoretical or a practical one. The most direct and basic approach to the understanding of a taxonomic unit is that of genetics, but this is a lengthy process which must be carried out under controlled conditions, and is in consequence limited in significance in phylogenetic studies. Likewise, the corollary sciences of comparative physiology, biochemistry, and embryology have to date offered few data helpful to the systematist. Morphology remains today, as it has in the past, the basis of classification. Admittedly it supplies indirect evidence, but it is the best available expression of gene activity, even though it be secondarily modified by environment, and by functional demands. Thus taxonomy has matured in theory and interpretation, due to the prescience of a few individuals such as G. G. Simpson; yet its method has remained essentially the classical one, and this monograph is no exception.

It is of considerable significance to zoologists that an authority of the author's experience and broad biological interests has published such a comprehensive work. The classification is based upon twenty years of extensive research on fossil forms and considerable study of recent ones, and it represents the latest and in many ways the most representative work on the subject. The field which has been covered is enormous, both as to specimens studied and literature examined and the opinions and conclusions of the author are presented, rather than the data from which they have been drawn. This work is thus a personal synthesis rather than a review of the subject, and this would seem to be a weakness. This feeling of the reviewer is recorded with full cognizance of the limitations of time and space in the treatment of any subject. However, the reader will be aware of a considerable arbitrariness in the author's decisions of which papers and data are worthwhile and which are not.

One major defect is evident, and that is in the treatment of the body exclusive of the skeletal and dental systems. This is particularly pointed, inasmuch as the author has made a strong plea in his introduction for the use of all applicable evidence in the building of classifications. It goes without saying that paleontological data are limited to ossified tissues, and extinct forms include two-thirds of mammalian genera. The treatment of living forms, however, has suffered measurably in that the muscular, nervous, and visceral systems have been so scantily and unevenly considered in the text, or even cited in the bibliography. Such omissions are present in the treatment of almost every order, and in some, many important papers on the skeleton itself have been overlooked. In numerous cases the omitted evidence is not in agreement with that of the skull, in many others it supplements it in a significant manner; in any event, such morphological data are concerned directly with the structure of mammalian types. It is to be regretted by all biologists that in a monograph rightly destined to exert an appreciable influence on the training and point of view of taxonomists the world over, such an important limitation is present.

The magnitude of the task of an authoritative appraisal of all mammals, past and present, is extreme, and the final evaluation of this, as of any other book, will rest upon the judgment of the future. It seems certain that this work will stimulate further progress in the field, and that it fills the pressing need of a revision based on the important fossil finds of the last twenty years.

JAMES M. SPRAGUE

THE MAMMALS OF MINNESOTA. *Minnesota Department of Conservation, Technical Bulletin No. 2. By Gustav Swanson, Thaddeus Surber, and Thomas S. Roberts. Minnesota Department of Conservation, St. Paul.* Paper. 108 pp. 1945.

After an introductory chapter on the vanished mammals of Minnesota, by Roberts, there follow short accounts by Swanson and Surber of fossil mammals, big game and fur-bearers, the conservation, collecting, and economic importance of mammals, and brief surveys of two groups of the smaller forms: the rodents and the insectivores. The largest portion of the bulletin consists of a systematic catalog of Minnesota mammals, by Swanson. Each species is given a brief description, including color, size, and sometimes dental formula, followed by data on its status and distribution within the state. The subspecies that have been shown to occur for a particular species within the state are given at the end, and in cases where more than one has been found, their individual ranges are outlined. Although unpretentious in appearance, the bulletin nevertheless supplies all the present-day information on Minnesota mammals. One little item that was pleasing to see was a drawing showing the patterns of the upper molars of six different species. This is especially useful for differentiating between *Microtus pennsylvanicus*, *chrotorrhinus*, and *ochrogaster*. Many a larger volume on mammalogy has discussed these

differences in reams of paper filled with words, but with never a use of a clear and simple drawing. A small thing, yet how valuable to the novice! There are several photographs, mostly by Surber, and drawings by Breckenridge and Poole.

HENRI C. SEIBERT

ECONOMIC ZOOLOGY

FISHERY RESOURCES OF THE UNITED STATES. *Letter of the Secretary of the Interior Transmitting Pursuant to Law, a Report on a Survey of the Fishery Resources of the United States and Its Possessions. 79th Congress, 1st Session, Senate Document No. 51.*

Fish and Wildlife Service, Ira M. Gabrielson, Director. United States Government Printing Office, Washington. 40 cents (paper). iv + 135 pp. 1945.

This report is a highly graphic, comprehensive summary of American fishery resources. Distribution maps, photographs, pictograms, and drawings illustrate the concise text and the statistics. The conclusions drawn are that the highly valuable fisheries are the most poorly managed of all our national resources, because of inadequate support of conservation agencies, because of continued water pollution, and because of the unprogressiveness of the commercial fisheries. It is recommended that:

1. The Federal expenditures, (a) for the benefit of United States fisheries be raised to a level comparable with those made for other food industries; (b) for the conservation and development of its fishery resources be made sufficient to accomplish their purpose.
2. The Congress authorize the Fish and Wildlife Service to organize a dynamic program that anticipates the needs of the Nation's fishery resources as a whole.
3. The Congress authorize the Fish and Wildlife Service to cooperate actively in its scientific research with all the countries that share with the United States common fishery resources.
4. Federal legislation be enacted to provide for: (a) Federal control of water pollution; (b) coordination at the national level in planning, construction and operation of all projects which involve the use of water, with full representation by the United States Fish and Wildlife Service.

This report will be of special interest to conservationists, ecologists, economic zoologists, and fishery people. It should also reach a much wider group: teachers of biology in colleges and secondary schools, students, and all forward-looking citizens. By making it available so cheaply, the U. S. Government continues to rank foremost as a publisher of scientific material at low cost.

BENTLEY GLASS

SALMON MARKING IN NORWAY 1938, 1939, AND 1940. *Det Norske Videnskaps-Akademi i Oslo. I. Mat.-Naturv. Klasse. 1941. No. 10.*

By Knut Dahl and Sven Sømme. Jacob Dybwad, Oslo. Kr. 5,00. 52 pp.; 9 plates. 1942.

ANIMAL MORPHOGENESIS

BIOLOGIE DES JUMEAUX (*Polyembryonie et Gémellité*). *La Science Vivante.*

By Maurice Caullery. Presses Universitaires de France, Paris. 80 fr. (paper). 168 pp. + 4 plates. 1945.

This small semipopular book deals in turn (1) with experimental and natural duplication of individuals during embryogeny, (2) with twinning in man and the domesticated mammals, and (3) with teratological twinning.

The first section of the book describes the natural and experimental production of twins in invertebrates and in vertebrates, and also briefly describes polyembryony as it occurs in certain invertebrates and in the armadillo. The section concerning twinning in man and the domestic mammals considers such subjects as the frequency of twinning, uni- and di-ovular twinning, twinning as it elucidates the study of heredity, and so forth. The author emphasizes repeatedly the value of studying twins 'as a criterion of the relative powers of nature and nurture," without, however, expressing any clear-cut evaluation of the results of such studies. The final section of the book reviews rather vividly the various types of double monsters which have occurred spontaneously in the domestic mammals and man.

The presentation is simple, straightforward, and clear, and the facts on the whole are presented accurately if not always critically. The author reports some very recent material concerning the stimulation of multiparity in sheep and cattle by injection of hormones (serum of pregnant mares), as described to him personally by Zawadowsky in June, 1945. The book, which gives a fair survey of the literature, is slight—indeed it makes no pretense towards being otherwise—and will probably be comprehensible and interesting to individuals who lack a specialist's training in this field.

JANE OPPENHEIMER

HOW A BABY GROWS. *A Story in Pictures.*

By Arnold Gesell. Harper and Brothers, New York and London. $2.00. vii + 80 pp.; 4 plates. 1945.

How a Baby Grows might easily be put in the class of a movie educational "short"; not a talkie, but one of bygone days when the sub-titles were printed. In

this day of visual education the reader will appreciate the author's method of relating the story of a child's growth and development in its first five years by means of 800 photographs arranged chronologically.

There are 34 sections of pictures and word descriptions. The pages are arranged so that each section has one page carrying an average of three short paragraphs of verbal description opposite the page of small pictures arranged in an orderly sequence. The child's social, mental, and physical experiences as he interprets "the world of things" and "the world of persons" are clearly portrayed through these pictures. The lack of sharp detail in some of the photographs is to be regretted, as failing to portray the superb material adequately. However, the multiplicity of pictures helps to compensate for this lack.

How a Baby Grows is definitely not meant as an addition to the Gesell library of study aids in the subject of child development. That it is not concerned with the reasons why a child behaves as he does, but with the fact that he does behave in certain ways, indicates that the book is designed for popular appeal. The selection of the material and the organization of this book show the same kind of scholarly and scientific work which characterizes all of Gesell's publications about the child.

CLAIRE QUINCER

THE SEXUAL MATURING OF SALMON. (*Salmo Salar L.*) *Det Norske Videnskaps-Akademi i Oslo. I. Mat.-Naturv. Klasse. 1944. No. 7.*

By Knut Dahl and Olaug Mathisen Sømme. Jacob Dybwad, Oslo. Kr. 4,00. 41 pp. 1944.

ANIMAL MORPHOLOGY

PRACTICAL ANATOMY OF THE RABBIT. *An Elementary Laboratory Text-book in Mammalian Anatomy. Seventh Edition.*

By The Late B. A. Bensley. Revised and edited by E. Horne Craigie. The Blakiston Company, Philadelphia. $3.50. xii + 358 pp. 1945.

Biologists everywhere will welcome this seventh edition of the late B. A. Bensley's useful book. For the benefit of those who are not familiar with this volume, it is important to emphasize the subtitle, for this is in fact an elementary textbook of mammalian anatomy. The well tried directions for the dissection of the rabbit comprise considerably less than half the book. The remainder, written for the beginner, constitutes a clear and readable introduction to vertebrate anatomy, dermal denticles of the shark included.

Is it permissible to hope that when the eighth edition appears, some of the illustrations will be improved? Many are admirable, but others do seem deficient. The general usefulness of the book, already great, would be still further enhanced if the standards found in Eunice Greene's *Anatomy of the Rat* or even better in Hartman and Straus's *Anatomy of the Rhesus Monkey* were to be approached.

GAIRDNER MOMENT

AN INTRODUCTION TO PHYSICAL ANTHROPOLOGY. *By M. F. Ashley Montagu. Charles C. Thomas, Springfield, Illinois.* $4.00. xiv + 325 pp. + 1 chart. 1945.

To introduce adequately the entire science of physical anthropology is an ambitious and difficult undertaking. In this comparatively young science much more remains to be done than has been accomplished so far, and many present claims and conclusions are as yet only tentative. Hard work and critical judgment are needed to collect and select the sound and significant information with which to outline in a comprehensive, balanced, and reliable manner the present status of the science of man as a physical being.

The author deals mainly with the following general topics: Description, origin and evolution of primates; origin and evolution of man; "ethnic groups" of recent man; heredity and influence of environment upon man; and "the relation between body, mind, and culture." In the detailed selection and treatment of the subjects presented one misses many important, concrete results, but finds instead long, argumentative passages with little, if any, bearing upon the science to be introduced. Thus, age changes, phylogenetic adaptations, secondary sex characters, etc. receive very insufficient attention, yet behavior, culture, intelligence, criminality, and other irrelevant subjects are discussed at great length in this small book on *physical* anthropology. If anywhere, in an *Introduction* one should insist on thorough reliability, but in this respect the book is defective. To mention only a few random samples of the many false statements: "As among lower mammals, the tear duct in the lemurs opens on the face and not inside the nasal cavity"; in marmosets, the tail "is covered with hair on all but its under surface"; "the night monkeys are the smallest, in body size, of the Cebidae." The list of twenty-two "principal anatomical features distinguishing man from the non-human primates" contains at least six wrong items. In addition there are innumerable claims of very doubtful validity. Why, for example, should the reduction of the thumbs of spider monkeys be "significantly associated with the highly developed prehensile power of the tail," if guerezas, which have also lost their thumbs, possess no prehensile tails? Why should the median ridge on the nasal bridge of the gorilla be "formed by the early fusion of both nasal bones," if there is no such ridge in any of those other

primates in which the nasal bones fuse at an earlier age? Why call the small ears of Negroids "specialized characters," if they are proportionately larger than in many apes and monkeys? Why, after listing strictly morphological investigations on racial hybridization, jump to the unsupported conclusion that "all these studies, and a great many more, prove the great value, from every possible point of view, of hybridization"? Minor errors are more numerous than can be exclused. For instance, there are no such animals as "Galadidae" or "Onomys"; the genus *Ateles* ranges from Mexico, and not from "Guiana," southward; to give the distribution of *Oedipomidas* as "Costa Rica to Central America" may be original, but is not very helpful.

An appendix is intended to present the "methods of measurement in physical anthropology," but is limited to the outer body and to arbitrarily selected as well as very inadequately defined recommendations. For instance, three very similar measurements are given for the height of the lower extremity, yet there is no reference to any pelvic or hip diameters; eye- and skin-color are mentioned, but not hair-color; tooth-extractions are to be "carefully noted," but the shape of the nose, distribution of hair, etc., have been totally ignored.

It is fortunate that we already possess many other and better books which can serve as introductions to the various phases of physical anthropology.

A. H. SCHULTZ

A METHOD OF ANATOMY. *Descriptive and Deductive. Third Edition.*

By J. C. Boileau Grant. The Williams & Wilkins Company, Baltimore. $6.00. xxiv + 822 pp. 1944.

The body of man has been dissected and described far more frequently and thoroughly than the body of any other animal, and books on the anatomy of man are more numerous and much more detailed than are anatomical monographs on other mammals. To justify an addition to the abundant collection of existing textbooks of human anatomy one must change the point of view and method of presentation, but one cannot make significant changes in the facts already so often and so fully recorded. As the title of this volume indicates, the author stresses the method of guiding the student to and through the vast accumulation of anatomical knowledge. Instead of arranging the subject according to the various systems of structures, as in the great majority of textbooks on human anatomy, the descriptions are here presented chiefly in topographic order, in relation to different regions and anatomical units; and frequent reference is made to functional causes and consequences of morphological findings. As such, the book follows essentially the practical program of instruction customary in American medical schools. This text, therefore, can be more easily appreciated by the student during the progress of his work in the dissecting room, than the ponderous, systematic treatises which serve for constant and detailed reference.

Though not intended as a guide for the dissector, this *Method of Anatomy* contains many practical directions for study. First of all it is designed "to be of direct application to the problems of medicine and surgery." Relatively little attention has been given to embryology, comparative anatomy, physical anthropology, teratology, history, etc., fields which can contribute so much to the teaching of anatomy as a science. Without comparisons, human anatomy remains a bare collection of dry facts which, though useful for medicine, have very limited scientific meaning and little philosophical appeal. The book contains no bibliographic references to lead the student to the sources of information or to allied fields of knowledge. The Birmingham Revision of the B. N. A. terminology has been employed in this work, though it would seem preferable to postpone changes in nomenclature until an internationally accepted, final revision becomes available.

As a practical, clear, and authoritative guide in learning the construction of the adult human body this book is undoubtedly very effective and can be highly recommended. It first appeared in the fall of 1937. The present, third edition has been partly re-written and re-arranged, and 55 new illustrations have been added. The new edition contains a generous total of 729 original, diagrammatic text figures. These are particularly useful because they have been kept as simple as was feasible and thereby supplement to great advantage the beautiful, realistic atlas by the same author.

A. H. SCHULTZ

"YOUNG MAN, YOU ARE NORMAL." *Findings from a Study of Students.*

By Earnest Hooton. G. P. Putnam's Sons, New York. $2.50. xii + 210 pp. 1945.

There are very few scientists, I venture to say, who could have taken the enormous amount of data upon which this book is based and have digested, analysed, and presented it so entertainingly effectively and clearly as Hooton has done in this volume. If, nevertheless, the book is not easy reading the fault is not the author's, for the sheer quantity of facts with which it bristles on almost every page demands careful and painstaking attention—a devotion which it will well repay.

The Grant Study of the Department of Hygiene of Harvard University has for the last half dozen years been investigating a sample of 268 normal Harvard students, with a view to arriving at some knowledge of

the whole man. With this purpose a staff of highly competent physicians, psychiatrists, psychologists, physiologists, anthropologists, and sociologists have attempted to analyse out the variables involved and to discover such correlations of significance as might exist between any of them. Hooton, who was in no way associated with the project, was called in to write a non-technical account of their work, which would be comprehensible to the general reader. He has done an excellent job. He is fully aware that the sample is a selected one and that it is too small for any really bomb-proof generalizations to be based upon its findings. The value of the work lies principally in the suggestive quality of the correlations which have been obtained, as well as in the quality of those which have not, and in its demonstration of the ideal manner in which the analysis of the whole person may be more or less successfully approached. Those who plan or have in progress similar studies would do well to consult this volume and the official report (which I have not seen) of the Grant study, recently published by the Harvard University Press.

It would be impossible within the scope of a short review to give any account of the results obtained by the Grant Study. The interested student will have to go to the Hooton or the Harvard volume or both for further details. This study represents a pioneer investigation of considerable importance, not so much perhaps, for what has already been achieved as for the improved model it provides for further heuristic exploration of the whole person in his biosphere.

The usual Hootonisms are to be found peppered throughout the book, and the biologistic bias is as strongly in evidence as ever, but at least Hooton plays this game divertingly enough to make the performance amusing to the onlooker, even if, like Mrs. Micawber, he abets his unnatural feats by playing the barrel organ.

It will be clear to the informed reader from this, and from his other writings, that Hooton does not really understand the nature of those "processes of heredity" the operations of which conjure up those nightmares of horrid form and face which he is so much concerned to abolish. This "heredity" is largely a figment of his own imagination. It is perfectly clear that he considers that the genes (potentialities) which enter into the formation of personality, which participate in the determination of some aspects of a person's intelligence and behavior, operate in precisely the same manner as do the genes for color-blindness, hemophilia, Huntington's chorea, and the like, that their degree of plasticity in relation to the environment is about the same. Whereas the fact is that while the expression of the genetic factors determining the latter are not (at present, at any rate) amenable to the influence of the postnatal environment, those which find partial expression in the former assuredly *are*. In the latter case it is not the genes that are influenced but the manner of their expression.

Most holistic students of man are, I believe, agreed that genes play an extremely important *part* in determining man's behavior, but only a part, and that part principally as potentialities organized under the effects of a culturalizing environment. Human behavior is not genetic behavior, but the socially organized and developed expression of inborn potentialities. The evidence is quite clear that the vast majority of human beings possess such potentialities as under the proper social conditions would find a highly desirable form of expression. This is what Hooton cannot see. It is quite obvious that he has been overimpressed by and misled into generalizing the very real and serious effects of genetic conditions which are to the largest extent unaffected by environmental processes, to those which are so affected, but which owing to failures in the environmental processes, result in serious defects in behavior. It is not the genes which stand in the dock with Hooton's "defectives," but the society which failed them.

M. F. Ashley Montagu

The Principal Nervous Pathways. *Neurological Charts and Schemas with Explanatory Notes. Third Edition.*

By Andrew Theodore Rasmussen. The Macmillan Company, New York. $3.50. ix + 73 pp. 1945.

This is the third edition of a popular and extremely useful book on neuroanatomy which first appeared in 1932. It is not intended to replace the textbooks in this field, but rather to supplement them. The material is clearly presented in the form of 28 excellent charts and schemas, each of which is accompanied by a brief explanatory text that includes correlations of structure and function.

The changes from the second edition, published in 1941, are largely minor in nature. They have been made in order to keep the figures and text abreast of well-established advances in the field. The major alterations concern the auditory and the extrapyramidal motor pathways.

The Romance of Human Architecture.

By Maurice Chideckel. Bruce Humphries, Boston. $2.00. ix + 107 pp. 1945.

In this little volume, the author has discussed the broad aspects of gross anatomy as exemplified by the organ systems of the human body. Intended primarily for the lay reader, it is presented in a clear, precise, and non-technical manner.

Although the text is concerned primarily with structure, sufficient reference is made to associated function to provide a general understanding of the normal working of the human body. Throughout the volume, the

author has emphasized the wonders of life and of nature as exhibited in the plan and the structure of the human organism.

The work is particularly well adapted to the type of brief survey course now being offered to returning veterans by many schools. A table of contents is provided, but there is no index.

B. AUBREY SCHNEIDER

ESSENTIALS OF HISTOLOGY.

By Margaret M. Hoskins and Gerrit Bevelander. The C. V. Mosby Company, St. Louis. $3.50. 240 pp.; 2 plates. 1945.

This is a little book dedicated to mediocrity. There are about half as many figures as pages. This redeeming feature is largely nullified by the lack of detail in the figures and the retention in them of artifacts and other errors (such as in the diagram of the renal blood vessels). Introductory students should be spared this "throwback" to the last century.

I. GERSH

ANIMAL PHYSIOLOGY

HOWELL'S TEXTBOOK OF PHYSIOLOGY. *Fifteenth Edition.*

Edited by John F. Fulton. W. B. Saunders Company, Philadelphia and London. $8.00. XXXV + 1304 pp. 1946.

This revision of Howell's textbook of physiology was undertaken by John F. Fulton and a large group of contributors, most of whom are associated with Yale University. Although, as suggested by the editor, the excellent prose style of previous editions has not been equalled, the revision has many excellent qualities which justify commendation. The organization of material is good; illustrations are excellent, and recently acquired information concerning the mechanisms of function of various systems and tissues has been incorporated in the text. The book contains ten major divisions: 1, Principles of nervous and muscular activity; 2, The central nervous system: motor function; 3, The central nervous system: sensory functions; 4, Properties and constituents of the blood; 5, Physiology of the organs of circulation of the blood and lymph; 6, Respiration; 7, Body fluids and kidney; 8, Physiology of digestion and secretion of the alimentary tract; 9, Metabolism and nutrition; 10, Physiology of reproduction. The subdivisions dealing with the electrical properties of nerve and muscle, functional properties of neurons, intercellular transmission and principles of spinal reflex activity are most excellent detailed presentations. These are of such high quality that professional physiologists will find them of great value, even though students may feel that these chapters violate, to some degree, the first of Howell's guiding principles, simplicity in the presentation of facts and theories. The chapters devoted to a consideration of the motor and sensory functions of the central nervous system are likewise complete and well done. Major emphasis is placed on the subject matter of these divisions, since practically half the total text is devoted to nerve, muscle, and the central nervous system. Sections dealing with blood and the cardiovascular system are equally well written and are adequate to meet the needs of the student.

If it is the duty of a reviewer to criticize as well as to commend, this obligation can be satisfied by pointing out a few imperfections. An observant student will find a clear difference of opinion expressed concerning the validity of Starling's law of the heart and the effect of increases in initial length on the vigor of contraction of skeletal muscle. If statements made on page 792 are compared with those on pp. 38 and 52, this contradiction is very apparent. It can likewise be pointed out that students will have difficulty obtaining information concerning the function of certain endocrine glands. If one should wish to increase his knowledge of the function of the parathyroids or to learn what is known concerning the cause of myxedema he would have difficulty. Despite these and numerous minor defects the reviewer's feeling is certainly one of admiration for the group which has produced this excellent addition to the few textbooks worthy of use by advanced students of physiology.

CHANDLER MCC. BROOKS

TIEREXPERIMENTELLE UNTERSUCHUNGEN ÜBER DIE WIRKUNG LANGDAUERNDER FOLLIKELHORMONAPPLIKATION UND DIE HORMONALE TUMORENTSTEHUNG.

By Hubert von Wattenwyl. Benno Schwabe and Company, Basel. Fr. 24.00. 235 pp. + 12 tables. 1944.

Prolonged treatment with estrogenic substances gives rise to the formation of fibromyomata in guinea pigs. This important discovery of Lipschütz and his associates was the starting point for the author's interesting research. Besides confirming Lipschütz's original observation, he has made a valuable contribution to the problem of the relationship of the estrogens to tumor formation. Although estradiol even in great doses never produced true carcinomata in the guinea pig, the incidence of spontaneous fibromyomata was greatly enhanced in this species. Estradiol therefore cannot be considered as a true cancerogenic substance, but rather as a stimulant of spontaneous growth of tumors. Although in human beings a correlation between treatment with estrogens and tumor formation never has been established, the possibility cannot be ex-

cluded that continuous treatment with large doses favors the transition from latent disposition to manifest malignant growth. As a safeguard, the author recommends cyclic treatment with physiologic doses.

Continuous treatment with estrogens also leads to histologic changes in the endocrine system. The histologic changes in the pituitary gland and in the adrenals are well described and illustrated with excellent microphotographs. Wattenwyl's report contains a wealth of information on the action of estrogens. This information is gained from the author's extensive observations and from the literature. The bibliography lists 550 papers and refers to many less known investigations. Wattenwyl's stimulating book can be warmly recommended to every biologist interested in the problems of normal and malignant growth. The publishers deserve great credit for bringing out this beautifully illustrated and printed volume under the difficult conditions of war-surrounded Switzerland.

WALTER FLEISCHMANN

ENDOCRINE MAN. *A Study in the Surgery of Sex. By L. R. Broster. Foreword by Sir Peter Chalmers Mitchell. Grune and Stratton, New York.* $3.50. xi + 144 pp. 1945.

The subject matter of this little book is at once more diffuse and more limited than its title suggests. Approximately the first half is taken up with a discursive treatment of elementary natural history, genetics, and evolution, from which a transition is effected, via the nervous system, to the endocrines. Here, the main emphasis falls upon the adrenogenital syndrome, with which the author and his associates at the Charing Cross Hospital have enjoyed considerable experience. One is conscious of a point of view limited largely to the findings of this school, and the reader may be at pains to distinguish dogmatic interpretation from fact, even in this field where the author is most at home. *Endocrine Man*, in short, represents a very personal document—an attempt to relate the author's metier, surgery, and in particular adrenal surgery—to some of the scientific and social implications of this work. The final chapters, on symbiosis and parasitism, and on the nature of man, belong in the realm of literary privilege.

H. R. CATCHPOLE

ANIMAL NUTRITION

FOOD FOR THE WORLD. *Edited by Theodore W. Schultz. University of Chicago Press, Chicago.* $3.75. xiv + 353 pp. 1945.

This timely book is a compilation of essays written under the Norman Wait Harris Foundation program of the University of Chicago. The essays were prepared for the Twentieth Institute of the Foundation, and bring together the contributions of research in nutrition, agricultural economics, population, and international relations. A fine introduction by the editor gives a brief review of the subjects discussed in the book. The twenty-three essays fall into six groups.

The first group of essays, on "The Food Movement," consists of two essays suppying general background: The International Food Movement in Retrospect, by Frank G. Boudreau; and The Experience of Adjustments Relating to Foods and Nutrition, by John D. Black. Both of these essays are well written and give clear, concise information.

The second group, on "Population," contains an article on Population—the Long View, by Frank W. Notestein; and a second, Population as a Problem in Quality, by Frank Lorimer. These contribute an extensive discussion of the future population, both as to size and kind.

The third group of essays deals with "Nutrition," and consists of five essays: Advances in Nutritional Research and Welfare, by C. A. Elvehjem; Knowns and Unknowns about What Constitutes an Adequate Diet, by L. A. Maynard; The Contribution of Nutrition to Food Policies, by Paul R. Cannon; Awareness and Attitude of the Medical Professions toward Food in Relation to Health, by Ancel Keys; and The Usefulness and Validity of the Dietary Allowances, by Lydia J. Roberts. These critical studies summarize the most recent findings in nutrition.

The fourth group, "Food Supplies," consists of six essays: The Marriage of Nutrition and Agriculture, by Karl Brandt; Food Supplies in Prospect after the War, by Walter W. Wilcox; Agricultural Adjustment and Nutrition, by Howard R. Tolley; Food and Income, by P. Lamartine Yates; Obstacles to Better Nutrition despite the Large Supply of Food in Prospect, by Margaret G. Reid; and Measures to Improve the Growth of the Demand for Food, by E. W. Gaumnitz. Here the general topic of food supplies is discussed, looking forward to the post-war world.

The fifth group, entitled "International Relations," considers this most important subject in six essays: Postwar Trade Policy, by Percy W. Bidwell; The Future of Commodity Agreements, by Edward S. Mason; Food as a Facet in International Trade, by Leroy D. Stinebower; New Horizons for Food and Agriculture, by Paul H. Appleby; The Contributions of a Permanent International Organization on Food and Agriculture, by Allan G. B. Fisher; and Major Obstacles in the Path of International Collaboration in Food and Agriculture, by Henry C. Taylor. These are scholarly, critical discussions of crucial problems.

The concluding group of essays, dealing with "Consequences and Policy," comprises Food and Agriculture in a Developing Economy, by Theodore W. Schultz;

and Basic Elements of an International Food Policy, by Karl Brandt. These reveal the steps necessary in laying out the basic elements of an international food policy and the challenge confronting our postwar world.

At the end of each group of essays there is recorded the discussion of the panel participants to whom the essays were originally presented. There is a complete index. The authors of these essays are authorities in their respective fields, and the information and opinions which they express so clearly and concisely here are well worth general consideration. The book is one of universal interest, particularly under present world conditions.

MARGUERITE M. SCHMIDT

THE WORLD'S HUNGER.

By Frank A. Pearson and Floyd A. Harper. Cornell University Press, Ithaca. $1.50. 90 pp. 1945.

This brief but excellent analysis of the world's food problem is a good answer to those who maintain that all that is necessary is to bring more land into cultivation. There is indeed plenty of untilled land, but less than half of the total land area has good soil, only about one-third gets adequate and reliable rainfall, and unfavorable climate and topography eliminate a good deal more from consideration. The joint limitations leave only an estimated 7 per cent of cultivable land area, of which over half is now in use—and that, of course, the best half, the most productive, the easiest to till. On the other hand, while the per capita consumption of plant foods, the mainstay of life, is even now nearly on a par throughout the world, it would take four or five times as much animal food (meat, milk, eggs, cheese, etc.) to bring all peoples up to the level of the best-fed two-fifths. But land cannot be diverted from its use in raising the necessary plant foods to raising the desirable animal foods which require relatively so much more area and labor.

The authors believe that there is more hope in encouraging an increased production on the present acreage, by "more complete conservation of animal manures, the expansion of commercial fertilizers, the use of more machinery, more efficient livestock, new and improved varieties of crops, control of animal and plant diseases, and more double cropping." However, the increase in food will be gradual, and *slower than the increase in population.*

The world, the authors conclude, can support, on the Asiatic standard of living, nearly 3 billion persons; on the American standard, fewer than a billion, or less than half the present population. At the European standard, the present world population is just about right, but uniformity would require fewer persons in Asia and more in North America, other continents being less affected. Without curtailment of population, there cannot be freedom from either war or want. Europe, the authors think, will remain the danger spot.

These opinions and estimates are objective and are based on the best available data. However unpleasant, they cannot be shrugged aside. They are a valuable antidote for much unwarranted optimism.

BENTLEY GLASS

WHAT TO DO ABOUT VITAMINS.

By Roger J. Williams. University of Oklahoma Press, Norman, Oklahoma. $1.00. vi + 56 pp. 1945.

This brief and very simply written book presents in most adequate fashion the subject of the "nutrition everyone should know." It contains the clearest graphic mode of comparing the proportions of essential nutrients in a food in terms of daily requirements yet seen, and makes it possible, by consulting simplified tables, for anyone to plan a balanced daily ration with ease and rapidity. It would seem impossible to go beyond this book in making the subject of nutrition generally intelligible. The name of the author is an adequate guarantee of its trustworthiness.

BENTLEY GLASS

BIOCHEMISTRY

ANALYSIS OF FOODS.

By Andrew L. Winton and Kate Barber Winton. John Wiley and Sons, New York; Chapman and Hall, London. $12.00. xii + 999 pp. 1945.

This volume is one of the most complete compilations of methods and other necessary information for the food chemist. As the authors say in their preface, "the book is built about century old methods for the determination of foods in six groups."

At the beginning of the book, one finds a "Suggested Short Course in Food Analysis." This gives a few of the most important methods for the student food chemist. Following this, the Introduction contains, first, a chapter on apparatus, with descriptions, cuts, and brief comments about various types of supplies needed for food analysis. Next follows a chapter on reagents, standard solutions, and indicators.

The main portion of the book is divided into two parts: Part I, General Methods; Part II, Special Methods.

The General Methods include some brief general microscopic methods, with illustrations, physical methods, and detailed general chemical methods. These general methods are numbered or lettered so that a cross reference system can be used. The methods are grouped under: organic elements, constituent groups, water, protein, fat, "nifext", fiber, ash,

alcohols, vitamins, natural colors, artificial colors, and chemical preservatives. Pictures of apparatus assemblies are shown, reaction equations are given in some cases, and some tables of necessary data are included. References to the original literature are included.

Part II includes special methods for the analyses of cereal foods, fatty foods, vegetable foods, fruit foods, saccharine foods, alcoholic beverages, dairy products, animal foods, alkaloidal products, food flavors, leaven, and salt. The same general outline is used in this section of the book, which is complete in itself.

The methods are described most clearly, and are all-inclusive. Along with the preparation of reagents, the apparatus needed, and the methods of calculating results, the authors' personal experiences with a particular method are many times included. An excellent index follows the text. This book, because of its scope, clarity, and organization, is an indispensable one for workers in the field of nutrition.

MARGUERITE M. SCHMIDT

MICROBIOLOGY

VIRUS AS ORGANISM. *Evolutionary and Ecological Aspects of Some Human Virus Diseases. Harvard University Monograph in Medicine and Public Health Number 8.*

By Frank MacFarlane Burnet. Harvard University Press, Cambridge. $2.00. 134 pp. 1945.

It is a biologist's delight to read this little book, based on the 1944 Dunham Lectures at Harvard. The subject of viruses has generally been considered the domain of the pathologist or (more recently) the physicochemist. For all their outstanding contributions, it is clear that the first of these is concerned mainly with an accident in the natural history of viruses, while the second cannot go beyond the static properties of the individual, the virus particle. Burnet's approach, expressing views rather widespread but never set forth in such an articulate manner, is concerned instead with the dynamics of virus populations, and places the viruses, so to speak, squarely in the midst of the evolutionary scene. Cutting short verbal squabbles as to the "particulate," "molecular," "living" nature of viruses, the author expounds the basic concept of the virus as organism, endowed with the fundamental quality of homologous reproduction, together with the inseparable negation, mutability. Firmly asserting his belief in the self-reproduction of viruses and in their evolution by mutation and selection, the author discusses for a series of animal viruses the ecological and evolutionary aspects of their natural history.

Virulence is closely connected with the ability of a virus to survive. Invasiveness for unprotected, susceptible host-cells makes for survival, destructiveness for the host generally works toward extinction of a virus. Whether a virus strain will spread, be eliminated, or remain relatively constant depends on a delicate balance between rate of multiplication, virulence, and mutability of the virus, and the prevailing environmental conditions (host distribution, immunological reactions). For each individual case, this approach suggests new lines of investigation: studies of host ranges, of mutations affecting virulence, of conditions favoring epidemic outbursts. As a whole, it points to the need for more fundamental knowledge of the biology of viruses: how they multiply and mutate, what part of the metabolic machinery of the host they utilize, by what process they destroy the host cells. Clarification of some of these problems should be forthcoming as a result of a concentrated attack on some of the simplest virus-host systems.

Burnet's arguments for a regressive origin of viruses from other parasites, though supported by the suggestive analogy with the loss of synthetic abilities by mutation in *Neurospora*, may not be deemed satisfactory by all biologists, some of whom, aware of the similarities between viruses and the factors of heredity, will not readily discount the possibility that viruses originate from cells similar to their present or past hosts.

Altogether, this book focuses attention on a fundamental field of research wide open to the biologist, who surprisingly enough, has until recently left it to the one-sided, however keen, endeavor of the pathologist and bacteriologist.

S. E. LURIA

TRAVAUX DU LABORATOIRE DE MICROBIOLOGIE DE LA FACULTÉ DE PHARMACIE DE NANCY. *Fascicule XIV (1945).*

Société d'Impressions Typographiques, Nancy. 96 pp. + 13 plates. 1945.

This annual publication from the laboratory of Ph. Lasseur, at the Université de Nancy, apparently represents work done in the period of transition from the German occupation to the liberation of France. The pertinacity of Lasseur and his co-workers in continuing their researches under these difficult conditions, is to be commended. As in previous issues of the *Travaux*, the principal stress is laid upon comparative studies of the dissociated types of bacteria, as well as factors affecting the pigmentation of bacteria.

The eight papers may be summarized as follows: The species concept in microbiology is briefly discussed. When exposed to x-rays of varying intensities, nine species and dissociated types of bacteria failed to give the saltations reported by Nadson. In continuation of earlier work (reviewed in this journal, Sept. 1945, 20: 294-5), data are presented on the differentiation of *Bacillus mesentericus niger* Lunt and *B. lactis niger*

Gorini (Rb types), by altering the mineral and nitrogenous constituents of the synthetic culture media. The appearance of cultures of *B. aurantiacus tingitanus* type Rb was the same whether *d*-alanine or *l*-alanine was the source of nitrogen. With four species of chromogenic bacteria, low concentrations of biotin methyl ester stimulated the growth of the less vigorous S and Ra types, while the more vigorous Rb types were scarcely affected. A temperature of 37° C. favored the production of a violet-red pigment by *B. mesentericus niger* type Rb in a synthetic medium; while, at 25° C., a blue pigment was formed whose production was enhanced by traces of aneurine (vitamin B_1).

The current interest in antibiotics is reflected in the final article. The action of penicillin (Pfizer's penicillin sodium salt, 100,000 Oxford units) was tested against twenty-six species and dissociated types of bacteria, mostly non-pathogens. It is concluded that penicillin is more stable than is commonly supposed, and has a certain bactericidal action as well as the bacteriostatic effect.

WALTER C. TOBIE

HEALTH AND DISEASE

DAS GESCHWULSTPROBLEM IN CHEMIE UND PHYSIOLOGIE. *Wissenschaftliche Forschungsberichte naturwissenschaftliche Reihe, Band 57.*

Edited by K. Hinsberg. (Theodor Steinkopff, Dresden and Leipzig); J. W. Edwards, Ann Arbor, Michigan. $8.25. xvi + 434 pp. (1942); 1945.

This is essentially a discussion of the biochemical aspects of the tumor problem. The main sections of the book deal with the inorganic constituents of tumors, the organic constituents, and activators such as hormones, vitamins, and enzymes. There is also a chapter on the reticulo-endothelial system and its relation to malignant growth. The volume appeared in Germany early in 1942 and has recently been lithographed under the authority of the Alien Property Custodian.

In style and general point of view the volume suggests Stern and Wilheim's *The Biochemistry of Malignant Tumors*. It contains a very thorough treatment of the older literature, with the emphasis on work done in Europe. As so often the case with German "Handbücher," the value of this volume lies more in its completeness and in the total number of papers brought together (the bibliography numbers several thousand items) than in any critical selection of material, although definite attempts have been made by Hinsberg to summarize or resolve conflicting results. Certainly the volume is of value as a handy index to the older literature on the various phases of the cancer problem of interest to chemists.

Quite another line of interest lies in the things that are not contained in the book. The latest references of European origin are dated 1941, while American work is only presented for part of 1940. The journals *Cancer Research* and *The Journal of the National Cancer Institute*, which have become so essential a part of American equipment in this field, are not even mentioned, nor is there any reference to such subjects as the transmission of mammary tumors through milk, the newer work on viruses, or the effect of diet on tumors due to azo dyes. The importance of calories is barely indicated. Thus in a negative way the volume indicates that there really has been progress in cancer research during World War II.

C. A. BAUMANN

COMMON AILMENTS OF MAN.

Edited by Morris Fishbein. Garden City Publishing Company, Garden City, New York. $1.00. 177 pp. 1945.

This book is intended to convey to the layman some knowledge of the ills that are most apt to beset him. They have been selected from articles which have appeared in Hygeia, a magazine published by the American Medical Association, to further the education of the public in health and in the nature of disease. Judging from the articles published in *Common Ailments of Man*, Fishbein has succeeded in giving the layman most valuable advice. The articles dealing with the common ailments of man are written by recognized leaders in their fields. The language is simple and an understanding of such complex problems as allergy is made possible for the reader, even if he has only a minimal knowledge of the basic facts of biology. One of the best articles in the book is Paul Dudley White's essay on heart disease. It is written from the experience of a man who has treated thousands of patients suffering from diseases of the heart, and has given a great amount of thought to the problems of his specialty. The final paragraph of his paper, dealing with the prevention of heart disease, should be required reading for prospective cardiac patients—and who can say that he does not belong in that category? Herman L. Kretschmer gives an excellent account of the prostate gland and its diseases, with the aid of three well-chosen illustrations. Articles like Kretschmer's ought to be most helpful in destroying many prevalent misconceptions concerning the diseases of the genito-urinary tract. Not all articles are written with the same precision: Freud has been quoted as "teaching that sex maladjustment was responsible for all the mental and most of the physical ills the flesh is heir to." Such small errors do not detract from the usefulness of this valuable little book.

WALTER FLEISCHMANN

MEDICAL USES OF SOAP. *A Symposium.*

Edited by Morris Fishbein. J. B. Lippincott Company, Philadelphia. $3.00. x + 182 pp.; 16 plates. 1945.

This symposium, in small book form, written in sections by an imposing array of physicians and other scientists, appeals mainly to the dermatologist. Its most stimulating contribution lies in the discussion of the so-called "acid mantle" of the skin and the effect thereon of soaps versus soapless detergents in relation to the development of eruptions in the eczema-dermatitis category.

It is unfortunate that the authors were so reluctant to mention trade names. Physicians and public alike buy and use cleansing agents under trade names, not by long chemical formulae. If the book had furnished trade name examples of each product discussed, it would be much more useful to the practising physician.

H. HANFORD HOPKINS

HAHNEMANN: *The Adventurous Career of a Medical Rebel.*

By Martin Gumpert. L. B. Fischer, New York. $3.00. 251 pp., 1 plate. 1945.

The medical history of the nineteenth century offers undoubtedly few lives which are better suited for a romantic biography than is the life of Samuel Hahnemann, the founder of homoeopathy. Gumpert is a skillful writer and has made full use of the human interest that is provided by the battles, wanderings, and marriages of the great medical rebel, who started as a poor physician in a small Saxon mining village, and died in 1843, at the age of 88, in a princely mansion in Paris, then the center of Western civilization. The author makes Hahnemann's rebellion very plausible by presenting it against the background of the barbarous and ignorant medical practices of his time. For an adequate treatment of the relevant historical problem: what positive implications can homoeopathy have for present day scientific medicine (an interesting and serious attempt in this direction is O. E. Guttentag's essay in the *Bulletin of the History of Medicine*, October, 1940), the medium chosen by the author is not very well suited. Gumpert's book is interesting and entertaining. Within the limits of the now so fashionable hybrid race of semi-fictional biographies it is undoubtedly far better than most products of this kind, being well written, well informed, intelligent, and free of such all too cheap effects as fictitious direct speech.

ERWIN H. ACKERKNECHT

A SURGEON LOOKS AT LIFE.

By Richard A. Leonardo. Froben Press, New York. $2.00. 128 pp. 1945.

The author, already known for a number of recent books, here sets out his personal views on a variety of subjects, ranging from birth control to the ills of old age and to life after death. He touches on faith cures, psychosomatic medicine, sterilization, euthanasia and eugenics, heredity and environment, juvenile delinquency, and the good life. He weaves into his straightforward, sensible views a considerable amount of medical history that is interesting background. None of the subjects he has chosen to treat is probed deeply, nor does he write with much literary distinction—but neither is he guilty of the flagrant nonsense found in so many of the books written by medical men who fare afield. He should be an interesting man to know.

BENTLEY GLASS

THE DOCTOR'S JOB.

By Carl Binger. W. W. Norton and Company, New York. $3.00. 243 pp. 1945.

This book was winner of the 1945 Norton Medical Award, and it impresses the reviewer as having been an altogether worthy choice. The principal themes of the book are the relations between doctor and patient, on the one hand, and between the patient's body and mind, on the other. These are pursued through such subjects as recent medical changes; specialties and specialists; psychosomatic medicine, psychoanalysis, and psychiatry; stomach ulcers; allergies; tuberculosis; high blood pressure; convalescence; the prevention of illness; office, hospital, and outpatient care; and socialized medicine. Throughout these discussions Binger shows himself to be thoughtful, progressive, liberal—cherishing the good in the past, looking with hope to the future. Humor and insight combine to demonstrate a deep and consoling wisdom. One feels that Binger, who never talks about himself, must be a fine example of the ideal physician he describes.

One other word of praise must be said. The author's prose is fresh and forceful—not at all to be classed with the stumbling, stilted language of many medical men who have attempted to write in the past few years for the general public. Patients and doctors alike will enjoy and profit from reading *The Doctor's Job.*

BENTLEY GLASS

PSYCHOLOGY AND ANIMAL BEHAVIOR

THE 1944 YEAR BOOK OF NEUROLOGY, PSYCHIATRY AND ENDOCRINOLOGY.

Neurology edited by Hans H. Reese, Psychiatry edited by Nolan D. C. Lewis, Endocrinology edited by Elmer L. Sevringhaus. The Year Book Publishers, Chicago. $3.00. 712 pp. 1945.

This Year Book, as usual, is full of interesting contributions in the three fields indicated in the title. It is interesting to note that neurology receives 260 pages, psychiatry, 160, and endocrinology, 274.

The editor concludes that *The Precentral Motor Cortex* edited by Paul C. Bucy is the outstanding contribution of the year in the basic field of medical science. Military psychiatry is well represented, and considerable attention is given to various shock treatments. Child psychiatry also is well documented, and in this field Kanner's article on "Early Infantile Autism" seems to me the most important.

This volume is up to the standards now long maintained by the members of this series.

WENDELL MUNCIE

RECENT ADVANCES IN NEUROLOGY AND NEUROPSYCHIATRY. *Fifth Edition.*

By W. Russell Brain and E. B. Strauss. The Blakiston Company, Philadelphia. $5.00. xiv + 363 pp.; 12 plates. 1945.

The fifth edition of this well known work includes for the first time a great deal of material which is neuropsychiatric, in the sense of being of borderline interest to both professional neurologists and psychiatrists. For instance, there is considerable treatment of frontal lobe functions, prefrontal leucotomy, electroshock methods, presenile states, the hypothalamus effect and its disorders, electro-encephalography, headaches, etc. As usual, the authors have been very able in presenting the recent advances in the chosen field, and this book will save users a great deal of time which otherwise would be spent in combing the literature. They are to be congratulated on the extension of the material to the psychiatric field.

WENDELL MUNCIE

FUNDAMENTALS OF PSYCHIATRY. *Third Edition. Lippincott Essentials Series.*

By Edward A. Strecker. J. B. Lippincott Company, Philadelphia. $3.00. xvii + 222 pp. 1945.

This is already the third edition of a small manual prepared for the use of physicians, of whatever training, who are called upon to treat neuropsychiatric problems in either civilian or military situations. The fundamental clinical pictures, methods of examination, and methods of treatment are discussed briefly and clearly. There is an index and a glossary of terms. The book no doubt renders a considerable service for the purpose for which it was intended.

PSYCHIATRY IN MODERN WARFARE.

By Edward A. Strecker and Kenneth E. Appel. The Macmillan Company, New York. $1.50. viii + 88 pp. 1945.

In this little volume, the authors undertake a comparison of the psychiatric problems of World Wars I and II, and they make a very good case for the fact that the lessons of World War I were insufficiently and tardily heeded in the recent war, that the discoveries were essentially the same in both, with the rate of recovery by treatment methods essentially the same in the two wars.

There is an interesting chapter on demobilization which stresses the points that most men will make their own adjustment quite well and that readjustment is a cooperative process in which civilians must join. The book is very well written, and may be profitably read by doctors generally as well as by psychiatrists, since in large measure the psychiatric problems resulting from this last war will appear in the offices of general practitioners probably more often than in the waiting-rooms of psychiatrists.

WENDELL MUNCIE

MEN UNDER STRESS.

By Roy R. Grinker and John P. Spiegel. The Blakiston Company, Philadelphia. $5.00. xii + 484 pp. 1945.

This book includes the material of the author's experiences in Africa which was published separately, and the continuation of that work with the flying personnel at a rehabilitation center in this country. There are five parts to the book: the men, their background and selection, the environment of combat, reactions to combat—morale, reactions after combat, and civilian applications. This is a most interestingly conceived book. There is a vast amount of material in it.

The attempt to force material into the strict analytic pattern strikes this interviewer as being unfortunate, since there are less pedantic ways of reviewing the material with just as tenable consequences. The treatment situation is well discussed. As a book, it is well worth reading.

WENDELL MUNCIE

MAN, MORALS AND SOCIETY. *A Psycho-analytical Study.*

By J. C. Flugel. International Universities Press, New York. $4.50. 328 pp. 1945.

In this book, Flugel undertakes a much needed study of the psychology of morals, and brings considerable courage to the task, pointing out that in the past scientists have very conveniently side-stepped the issue

of values in the facts of life. He takes the ground that such a view of science is a limited one, limited to its "instrumental values as opposed to its intrinsic values." In a consideration of the intrinsic values: "there exists a whole hierarchy of values, each of which is a means to the value that stands just above it in the hierarchy. What from one viewpoint is an 'end' becomes from a wider viewpoint but a 'means'.... Indeed, the distinction between means and ends is largely arbitrary. At best there can be only a few unquestionably intrinsic values at the top of the hierarchy such as Truth, Goodness, Beauty ... there should strictly speaking be one only ... moral philosophers are not yet in agreement as to what this supreme value is." Flugel points out that the difference between a strictly psychological approach and a moral approach to the same set of problems involves a switch over from an orectic process in the latter to essentially a cognitive process in the former, and he concludes that the psychological process will prove more effective.

Subsequent chapters deal with conscience and will and various aspects of psychoanalytic theory as applied to the matter of conscience: for example, the origin and function of the ego-ideal, social approval and the ego-ideal, conflicts in the ego-ideal and some attempts at their solution, nemesism, aggression and sado-masochism, taboos, the Polycrates complex, vicarious punishment, projection of the super-ego, overcoming and evading the super-ego, wishful thinking, autism, and unrealism.

From all this psychoanalytic structural analysis, he concludes "we have learnt that morality is deeply embedded in the human mind. Man is indeed fundamentally a moral animal. But we have also learnt that much of his morality is crude and primitive, ill adapted to reality, and often at variance both with his intellect and with his higher conscious aspirations."

In order to develop the most benefit from the analytic study, the material is reduced to several topics which the author treats extensively, all of which constitute general tendencies in the psychology of moral progress:

1. From egocentricity to sociality
2. From unconscious to conscious
3. From autism to realism
4. From moral inhibition to spontaneous "goodness"
5. From aggression to tolerance and love
6. From fear to security
7. From heteronomy to autonomy
8. From orectic (moral) judgment to cognitive (psychological) judgment

Flugel undertakes in a separate chapter a discussion of the problem of religion. He speaks openly of the resentment against psychology as an intruder into a world of religious values, and he points out that this resentment springs from a deep fear that psychology, and psychoanalysis especially, will undermine or has already undermined religion or indeed disproved it. He states that psychoanalysis has indeed undermined religion in the sense that it has "reversed the old 'ontological argument' which deduced the existence of God from our idea of Him." On the other hand, he feels that psychoanalysis has given indirect help to religion in its struggle against the devastating attacks of applied science by raising in an actual form certain problems connected with the nature of truth and reality, and by undertaking the serious study of the emotions and attitudes involved.

In summary, he states:

1. That by revealing religious beliefs as elaborate social forms of 'autistic' thinking, psychoanalysis has reinforced the objections to the metaphysical implications of these beliefs that were already so plentifully forthcoming from the other sciences. But although it is calculated to make us additionally suspicious of the validity of these beliefs, it has no power to 'disprove' them.
2. That, on the other hand, by demonstrating the fundamental nature and infantile origin of the needs underlying religion, by revealing something of the intimate meaning and complex over-determination of its symbolism, by drawing attention to its value from the point of view of mental and social hygiene as a prophylactic against individual neurosis, and by raising certain subtle problems as to the 'reality' of different kinds of mental content, psychoanalysis endows religious belief with a significance far greater than that which we should be inclined to attribute to it from the standpoint of physical science.
3. That it reveals, above all, the great significance of the higher types of emotional attitude involved in religious experience, but at the same time indicates the possibility of attaining at least a comparable emotional attitude apart from metaphysical religious beliefs, the attitude thereby acquiring perhaps a greater 'reality' value.
4. That is shows at the same time that, alongside of its beneficent functions, religion in its cruder forms can exercise a severe crippling and inhibiting effect upon the human mind, by fostering irrational anxiety and guilt, and by hampering the free play of the intellect. In this respect religion mirrors the evil effects of the primitive internal super-ego, and in the long run even an increase in individual neurosis may not be too high a price to pay for the removal of the restrictions it imposes.

Flugel finds numerous similarities in the aims of Christianity and of psychoanalysis, the main difference being that Christianity "still speaks in terms of the projected divine father-figure, while psychoanalysis concerns itself with the internal father representative, the super-ego." He looks upon Christianity as an attempt to escape from the authoritarian father-figure by establishing a son-brother relationship, yet the guilt arising from the rebellion against the father demands a sacrifice of atonement. Moses had previously forbidden such atonement and had condemned his people to an unrelieved tension of their guilt which Christianity relieved by indicating that the atonement was in accordance with the will of the Father. With the guilt wiped out, non-violence was urged and this should have prevented a recurrence of guilt. This has not actually

been accomplished, apparently because the sense of guilt and aggressiveness are too deeply entrenched in man. The author finds Christianity lacking in its appeal to men of action, not offering them proper goals for their aggressive tendencies. He feels that religious emotions must be canalized along active and social lines if they are to serve humanity.

Flugel concludes that "men must abandon the last shred of that longed-for but illusory 'omnipotence' . . . men are in fact thrown back upon themselves and must rely on their own efforts to improve their lot . . . this very sense of loneliness and isolation may well serve to bring them closer together . . . they have the consolation of knowing that in the human heart and brain they possess instruments which, faulty though they be, have brought them far along the path of evolution, and, if wisely used, may bring them almost infinitely farther . . . if there is a purpose in evolution, we have no means of understanding it except in and through the mind of man. There is no guidance as to the nature and our place in it save such as we ourselves provide through the free use of human faculty."

The final chapters, "Left and Right as Social Attitudes" and "The Problem of War and Peace," furnish the proper sequels to the preceding material. Flugel concludes that in spite of the sinister tendencies in human nature which might well make one pessimistic, he joins L. Susan Stebbing in believing that "Human beings are too fine in their highest achievements to justify despair." This is a notable contribution and deserves most careful study.

WENDELL MUNCIE

THE PSYCHIATRIC NOVELS OF OLIVER WENDELL HOLMES.

Abridgment, introduction, and annotations by Clarence P. Oberndorf. Columbia University Press, New York. $3.00. viii + 268 pp. 1943.

Probably few biologists today have read much of the writings of Oliver Wendell Holmes. A certain number, perhaps, have scanned and admired the pithy comments of *The Autocrat of the Breakfast Table*, but very few will have ventured to open any one of his three novels. Oberndorf, professor of Clinical Psychiatry at Columbia University, has done a real service in reminding us that Holmes was a great doctor, far ahead of his times in his ideas. We may remember that Holmes shares with Semmelweiss the honor of having revealed the contagiousness of puerperal fever. We are not so likely to recall that he coined for Morton the word "anesthesia." We are most unlikely to recognize his anticipation of Freud and the modern school of psychosomatic medicine. As Oberndorf points out, the anticipations of Freud include the appreciation of the unconscious as the source of drives and urges, the mechanism of the free association of ideas, so important in psychoanalysis, the significance of dreams, and splitting of the personality. Holmes wrote his three novels—"medicated novels," they were called in disparagement—with the direct purpose of showing that absolute freedom of the will cannot exist because of the power of unconscious mental processes. This calls for charity and understanding toward many asocial and antisocial forms of conduct.

Elsie Venner (1859) is a study of a girl affected by a prenatal influence, a snake-bite suffered by her mother during pregnancy having endowed the child with a strange reptilian character. Geneticists will be interested in this now fantastic supposition! Heredity is at the root of the troubles of Myrtle Hazard, a typical hysteric, who is the heroine of *The Guardian Angel* (1867). *A Mortal Antipathy* (1884) is from a psychoanalytic point of view perhaps the most remarkable of the three novels. It depicts a "compulsion type of morbid fear. . . . In it Holmes approaches more significantly the psychoanalytic position of Freud—namely, that a personal shock or trauma in very early infancy may cause a conditioning which the individual sometimes does not outgrow."

The bulk of the present volume consists of abridgments of these three novels, effectively arranged so as to relate their stories while rendering completely those passages of marked psychological interest. Oberndorf has added extensive notes on these. The interest and value of the novels is readily apparent today. When they were written, however, "the social significance of mental deviation, so stressed by Holmes, had not been grasped by science or society." Geneticists and medical men, besides the psychiatrists, will be well repaid for examining them.

BENTLEY GLASS

BACK TO LIFE. *The Emotional Adjustment of Our Veterans.*

By Herbert I. Kupper, with a foreword by Robert H. Felix. L. B. Fischer, New York. $2.50. 220 pp.; 1 chart. 1945.

This is one of several books written in the last few years which purport to facilitate the satisfactory emotional adjustment of both the veteran and the civilian during the transition of a war-geared world to a world of peace. It pivots on the ex-serviceman and persons who will have direct interpersonal relations with him. The author is a progressive, young psychiatrist who not only writes authentically about men in Service, but who seems to sense the social currents in this Atomic Age. The style is chatty and in places, humorous. Case studies and quotations from youths in the process of adjustment to the "changed conditions" to which they have returned should produce insight in the reader. Abnormal dynamics are presented as extremes found within the range of normal processes.

The book opens with a presentation of the problem of the man, who, though he passed all screening tests, developed combat fatigue and broke down. He is fatigued and struggling to find his place in the world. He is shown to be not too different from his "normal" brother who came through the same hell with only residual nervousness. A chapter on the transition from a typical youthful civilian to a trained citizen-soldier hints at the strain that this change entailed. Brief, vivid case studies depict immaturity, trends of aggressiveness born of frustration, personal guilt, hatred for superiority engendered by parental mishandling, and fears of mutilation.

The G.I. sentimentally wants home to be as he left it, when he returns, and even though he reaizes he has changed, he wonders if what he left behind has not also changed.

In the fourth chapter the reader can obtain a psychological perspective on much of our present post-war dissensions. The conflicts and aggressive tendencies which modern, complex civilization produces may be mobilized against a common enemy in war. When the enemy is defeated and the object of the unified attack is removed, many scapegoats are sought. The minority groups become the object of aggression. The problems of sex, of conscious and unconscious homosexuality, and of promiscuity are considered in terms of social and individual causes.

The final chapter deals with "what to be done and how to do it." The "General Rules on the Treatment of Veterans" release by the National Committee for Mental Hygiene are reprinted. Brief simplified descriptions of modern psychiatric methods and clinics are presented. Inside the cover of the book are charts diagramming for the veteran actual sources of aid in solving most of his needs, ranging from the spiritual to the recreational.

Few criticisms can be lodged against this book when it is considered in the light of its purpose. College professors will find it useful in explaining the behavior of some of their present students.

FRED MCKINNEY

OUR INNER CONFLICTS. *A Constructive Theory of Neurosis.*

By Karen Horney. W. W. Norton and Company, New York. $3.00. 250 pp. 1945.

In this latest attempt to present "a constructive theory of neurosis," the author has approached the task from her special psychoanalytic standpoint, and while she only occasionally deviates from traditional Freudian teaching, the whole book is nonetheless permeated with an attitude which is a long way from the traditional psychology of the Freudians. The book will make a broad appeal to all those psychologists who work eclectically, and who are concerned primarily with the present, using the past only for whatever it can give in the way of illumination and understanding of the present. Karen Horney sees the basic conflict of the neurotic as a matter of his fundamentally contradictory attitudes toward other persons. She describes three general tendencies of the neurotic under the terms "moving toward," "moving against," and "moving away" from people. These tendencies, pure or mixed, can be observed in any neurotic.

The author discusses the patient's attitude toward his idealized image, the externalization of his conflicts, and certain "auxiliary approaches to artificial harmony," as defenses erected about the nucleus of the basic conflict. She describes the consequences of unresolved conflicts in the form of fears, impoverishment of the personality, hopelessness, and sadistic trends. Bolstered by her theory of neurosis, she confesses to optimism in regard to the resolution of neurotic conflicts, as opposed to the pessimism which she finds in the Freudian classical approach. She summarizes the therapeutic goal as "the striving for wholeheartedness: to be without pretense, to be emotionally sincere, to be able to put the whole of oneself into one's feelings, one's work, one's beliefs. It can be approximated only to the extent that conflicts are resolved." On a number of occasions, the author has stressed her concern about a psychology of morals. She states: "Because the patient's morals in part result from his neurosis and in part contribute to its maintenance, the analyst has no choice but to be interested in them."

The material is well presented,—in fact so well presented that the casual reader might conclude that everything has become easy now, in spite of the expressed statement to the contrary. Horney does a service to psychology in insisting that the human personality can change even after the period of childhood. I should think that many psychiatrists will find here a clarification of working principles and methods, which may be quite generally applied.

WENDELL MUNCIE

THE YEARBOOK OF PSYCHOANALYSIS. *Volume I. Edited by Sandor Lorand. International Universities Press, New York.* $10.00. 370 pp. 1945.

This Volume One of a yearbook designed to cover the important contributions to the field of psychoanalysis during the current year, has extended its scope back to 1942 in order to include some of the studies on war neurosis appearing prior to 1945. There is an impressive group of contributors and an impressive number of subjects. Some contributions are difficult reading except for the initiated.

As one who has been interested in the question of sleep disturbances, I find the article by Fenichel and some collaborators in a symposium on the subject a very severe experience in understanding. The Obern-

dorf story of hysteria, by contrast, is quite intelligible. I cite these differences because this is a book for general distribution, and certainly there will be many who are not psychoanalysts who will want to read the material in such a yearbook. It ought to be presented in the simplest common terms. Despite this criticism, I shall continue to buy successive volumes, and I think many others will do so too, and will find it useful.

WENDELL MUNCIE

EXPERIMENTAL CATATONIA. *A General Reaction-Form of the Central Nervous System and its Implications for Human Pathology.*

By Herman Holland DeJong. The Williams & Wilkins Company, Baltimore. $4.00. xiv + 225 pp. 1945.

In this monograph, the author brings together all the material on experimental catatonia which first started with his observations and those with Baruk, and followed later on by extensive additional experimentation with a number of collaborators in Europe and America.

Put briefly, he finds that catatonia is a general reaction-form of the central nervous system which can be brought about in experimental animals by the most diverse conditions, but principally by the injection of certain drugs, notably bulbocapnine, and by experimentally produced pathologic conditions in the liver or intestines. This latter is suggestive, as he finds that catatonic schizophrenics show an alteration of liver function, as determined by the cephalin-flocculation test, with much greater frequency than other schizophrenics or normal patients.

The book is replete with protocols of experiments and one cannot read the text without being impressed with the great number of variables at work when one approaches the problem even at its simplest level. The author concludes that cellular asphyxiation is the likely final common agent for the production of experimental catatonia of any origin, whether it be by chemical, biochemical, metabolic, electrical, neuro-surgical, anatomical, or numerous other means.

WENDELL MUNCIE

RORSCHACH'S TEST. II. A VARIETY OF PERSONALITY PICTURES.

By Samuel J. Beck; foreword by Roy R. Grinker. Grune & Stratton, New York. $4.50. xii + 402 pp. 1945.

In this volume, the author after a review of theoretical questions concerning personality and the psychologic significance of Rorschach test factors, embarks on the evaluation of specific Rorschach tests, showing scoring methods and interpretations with special reference to the intelligence curve, the adolescent years, schizophrenic solutions, neurotic struggles, and a comparison of test records before and after treatment in various conditions. This is a fitting supplement to his volume I, which dealt with more theoretical considerations.

PSYCHOLOGY OF SEX RELATIONS.

By Theodor Reik. Farrar and Rinehart, New York and Toronto. $3.00. 243 pp. 1945.

This is an unusual book which will find a large audience among the common people who believe that love is an essential part of a satisfactory sexual relationship. There are three parts to the book: "The Nature of the Sex-Drive"; "Love and the Ego-Drives"; and "Love and Lust." To this book the author brings a large analytic experience and reaches conclusions differing radically from Freud.

It is well written, easily understood, and will find a large measure of agreement with common observation. It is a book which can be read profitably by everyone.

WENDELL MUNCIE

THE ETERNAL ONES OF THE DREAM. *A Psychoanalytic Interpretation of Australian Myth and Ritual.*

By Géza Róheim. International Universities Press, New York. $4.50. xiii + 270 pp.; 4 plates. 1945.

The author here returns to the topic of Australian totemism. In this monograph he reverses his previous stand that Australian culture is an intermingling of a series of immigration waves and now accepts the view that Australian culture is an organic homogeneous unity.

In this book he discusses the meaning of totemic myth, the dual heroes, the origin of circumcision, fertility rites, the phallic ritual, the eternal ones of the dream, the totem sacrament, etc. He summarizes the material as follows:

"Our survey of the various aspects of totemic religion in a stone age people is now ended. The hero is Eros, the problem is that of human beings in relation to their environment. We have first studied totemic mythology as a projection of the initiation rite into the past. But the initiation rite is essentially the attempt of the old men to castrate the young, enacted as a separation of mother and son. The originators of the ritual are the dual heroes. They represent the body and the penis, but unconsciously, the mother and the child. The same interaction of genital castration significance and pre-genital, separation meaning, characterized the rituals of circumcision and subincision. The transition period is dealt with partly by identification and partly by phallic genitalization, both of which are basic elements in the tjurunga cult and ritual. The ambisexual symbolism of the tjurunga with the concentric circle on the penis symbol, of the ngallunga with the subincision hole on the penis, and of duality as repre-

sented in the symbolism of the rainbow and the serpent, all are attempts to master the trauma of separation. In totemic magic the destroyed mother is re-animated and in the totem sacrament, eternal union of child and mother is effected."

WENDELL MUNCIE

HUMAN BIOLOGY

RACE AND DEMOCRATIC SOCIETY.

By Franz Boas. J. J. Augustin, New York. $2.50. 219 pp.; 1 plate. 1945.

This volume reprints some thirty-odd brief papers and addresses to the general public by our late great American anthropologist. They range in time from the early years of this century to within a few months of his death in 1942. One finds a remarkable degree of consistence between his earlier and later views. Papers and addresses from 1919 and 1941 on the same theme may be presented in reverse chronological order without the slightest sense of incongruity. Boas' convictions only deepened with the years as he saw the rising tide of prejudice and "racial" hatred, the mounting threats to freedom of mind and spirit, the impending doom of totalitarian repression. Never was he afraid to speak out to the people—and every scientist may well read again these stirring, noble words and from them take fresh courage.

The essays are grouped into three sections: Race; Units of Man; Democratic Society. They survey the problems of racism, of nationalism, and of social justice. The relations of the teacher and scientist to society are probed with sage wisdom. Among his last words we read these sentences of dedication:

> . . . No matter how remote our subject may be from the urgent practical needs of our time . . . the ice-cold flame of the passion for seeking the truth for truth's sake must be kept burning, and can be kept alive only if we continue to seek the truth for truth's sake.
>
> But a new duty arises . . . We must see to it that the hard task of subordinating the love of traditional lore to clear thinking be shared with us by larger and larger masses of our people. We must do our share in trying to spread the art, and to engender the habit of clear thinking. It is not the spread of a superficial knowledge of the results of science that will accomplish this end . . .
>
> It must be our task to see to it that those who control education are permeated by the conviction that it is one of their prime duties, to set free the minds of the youth of our generation, so that the young may learn to recognize bias and prejudice, that they may become respectors of truth for the sake of truth. A people, so educated, will be free in the fullest sense of the term. It will more nearly approach the ideal of democracy than has been attained by any of us.

BENTLEY GLASS

PATTERNS OF CULTURE. *Pelican Books.*

By Ruth Benedict. Penguin Books, New York. 25 cents (paper). 272 pp. 1946.

The new American series of Pelican Books begins auspiciously with the reprinting of *Patterns of Culture*, already virtually an anthropological classic. The name of the author is a sufficient recommendation.

THE ART OF MEDICINE IN RELATION TO THE PROGRESS OF THOUGHT. *A Lecture in the History of Science course in the University of Cambridge February 10, 1945.*

By A. E. Clark-Kennedy. The Macmillan Company, New York; Cambridge, England, at the University Press. 75 cents (paper). 48 pp. 1945.

According to Clark-Kennedy, Greek thought owed its observational elements mainly to Greek medicine. In later periods it was rather the general progress of thought which influenced medicine than the converse. Under the impact of modern natural science our concepts of disease, as described in some detail by the author, differ considerably from those held by Hippocrates, Harvey, or Sydenham. Our attitudes in preventive medicine or in treatment have equally tremendously changed under the influence of modern physiology, genetics, and psychology. On the other hand, doctors of medicine have gone astray on a number of occasions, and are in danger of doing so more often, as they simply and blindly follow technical scientific progress. They lack mental coordination and a philosophy. The risk of "sinking in the sea of our widening knowledge" imposes upon medicine the duty of collaborating in an integration of the arts and sciences in university education in order to restore our sense of proportion and intellectual balance.

As the accent of the little book is laid entirely on the present situation, it would be beside the point to discuss here the author's historical opinions, some of which might be controversial. This short abstract can convey only a very inadequate idea of this courageous, thoughtful, and very stimulating lecture.

ERWIN H. ACKERKNECHT

THE EFFECT OF SMALLPOX ON THE DESTINY OF THE AMERINDIAN.

By E. Wagner Stearn and Allen E. Stearn. Bruce Humphries, Boston. $2.50. 153 pp. 1945.

This is the result of a year's delving into the history of smallpox vaccination to discover the sources of the belief that vaccination may endanger life. The authors discuss the history of smallpox among the American Indians, beginning with the sixteenth century records down through the twentieth century. The history of smallpox on this continent is "the history

of the conquest, settlement, and development of the American continent. From the moment of the arrival of smallpox with Cortez in 1520, it affected disastrously the destiny of the Indian, acting as a weapon in the hands of the white man, a weapon so powerful that it was feared by the red man much more than were bullets and swords. Not until the nineteenth century, when vaccination began to be practiced, had the Indian a chance for survival."

It is an astonishing thing to read that whole tribes of Indians disappeared under the impact of one or more episodes of the disease. The story is very well told, replete with documentation, and should leave no doubt in anyone's mind of the beneficial effects of vaccination on the control of the disease.

The final paragraph is particularly interesting: "If, in the foregoing pages, some facts have been stated which incriminated the white conquerors and settlers, the history is replete with instances of great heroism and devotion of large numbers of white men throughout the centuries, who laborered to alleviate the sufferings of, and finally brought protection to, the conquered people through vaccination at their own trouble and expense."

WENDELL MUNCIE

THE ROLE OF THE AGED IN PRIMITIVE SOCIETY. *By Leo W. Simmons. Yale University Press, New Haven.* $4.00. viii + 317 pp. + 2 tables. 1945.

The problem of old age has become one of the most crucial problems of our aging society. Knowledge of primitive practices is absolutely necessary for a proper understanding of its sociological and psychological implications. The first book in English on the subject is, therefore, most welcome. The author has collected data from 71 primitive tribes and correlates them, statistically and otherwise, with the general cultural traits of these tribes (economics, family system, etc.). He examines the mechanisms which allow survival to the aged in primitive societies: food-sharing habits, family structure, property rights, traditional prestige, the shift into minor physical activities, the assumption of leading roles in government, in the transmission of knowledge and folklore, and in cults and magic activities. He discusses the wide range in the circumstances of death, from respectful behavior towards the helpless to exposure and actual killing in relation to environmental resources.

The author has successfully overcome the great difficulties produced by the scantiness of relevant material. He has not only collected an enormous amount of interesting data, but has discovered a great number of significant reactions and relations. His book deserves the widest attention.

ERWIN H. ACKERKNECHT

PLANT GEOGRAPHY AND CULTURE HISTORY IN THE AMERICAN SOUTHWEST. *Viking Fund Publications in Anthropology Number Five.* *By George F. Carter. The Viking Fund, New York.* $1.50. 140 pp. 1945.

Too often in the past ethnobotanical writings have been primarily anthropological or archeological in nature, with little attempt to identify properly the plant material or to evaluate the botanical data. More recently there has developed a school which utilizes all available material, whatever its source, and calls upon many of the related sciences in an attempt to reach accurate conclusions.

The present work, which is essentially a study of the history of southwestern agriculture, follows this pattern. Not only are archeological, ethnological, and general botanical data presented, but evidence from such specialized fields as agronomy, genetics, taxonomy, plant geography, and climatology as well. The result is a logical and well organized presentation of the facts which support the author's conclusions. In this study of the domesticated plants of the Southwest and their cultural history the approach is from a geographer's rather than an agronomist's point of view, and much emphasis is placed on areal distribution. The supporting data were obtained primarily from field work, a study of archeological collections, and of plant geographical literature.

After giving a general historical background of the archeological and cultural areas of the Southwest, the author devotes some sixty-six pages to a detailed discussion of the principal domesticated crops (the cucurbits, maize, the tepary bean, and the kidney bean) with brief mention of lima beans and cotton. This is followed by a discussion of climate and its effect on crop distribution, especially as it is concerned with avenues of plant migration. The part irrigation played in the development of the southwestern cultures is also outlined. The presentation of this detailed material is followed by a general summary of the prehistoric crop and agricultural areas, giving their limits and their cultural and chronological relationships. The final chapter is devoted to the age of the southwestern cultures, as deduced from the evidence of plant domestication, and to a discussion of the time involved in domestication and its meaning for American archeology.

Briefly the essential conclusions reached are as follows: The agriculture of the Southwest was divided into *two* distinct areal groups, each with its own distinctive crops and differing in climate and culture as well.

A. The Gila-Colorado area (Piman, Yuman, and the older Hohokam cultures) with a specialized variety of pumpkin (*Cucurbita Pepo*), a single distinctive type of maize, and the tepary bean (*Phaseolus acutifolius*) as its chief crops.

B. The Plateau area (Anasazi (Basket-Maker and Pueblo) cultures) with the squash (*Cucurbita moschata*), several ordinary types of maize and the kidney bean (*Phaseolus vulgaris*), crops also found in the eastern United States.

This fundamental dichotomy of crops and areas goes far back in time. Neither one can be derived from the other nor from any immediate common source. It is consequently necessary to postulate two separate origins (western Mexico for the Gila-Colorado area; eastern Mexico for the Plateau area), and two widely separated routes of migration.

The route to the Gila-Colorado area followed the west Mexican coast through Sonora to the hot and arid desert regions, a route which was one of the chief trade and cultural arteries from Mexico northward. The crops which reached the Southwest along this corridor must have become very drought-resistant, heat-resistant, quick growing, and otherwise highly specialized.

The second corridor of plant migration was situated in eastern Mexico and led northward to Texas and the Mississippi Basin, from which area the crop plants moved into the eastern United States, and also westward to the Great Plains, eventually reaching the Plateau region of the Southwest; the migration probably occurred in successive waves. This eastern corridor had a more felicitous climate, and the Middle American crops proceeded northward with but little modification. This route functioned over a long period of time and was much more important to prehistoric development than the western route; and it had a much more varied plant assemblage.

The evidence that the Basket-Makers of the Plateau area derived their crops from the east necessitates the assumption that their culture was more recent than either eastern agriculture or that of the Hohokam in the Gila-Colorado area. This is a revolutionary idea, as the Basket-Makers have long been considered to be one of the earliest of American cultures.

The discussion regarding the age of the various types of agriculture is illuminating, since it, also, is at variance with established archeological timetables that place the first culture in Middle America as no earlier than 500 A.D. The ideas expressed are, however, in accord with the arguments presented by Oakes Ames in *Economic Annuals and Human Cultures*, and by Jones and other botanists. The evidence from plant domestication, "the basic datum point for discussing the antiquity for agriculture," indicates that a very long period of development (?2000–10000+ years) is necessary before any recognizable agriculture can be established. The actual beginnings may be as far back as the Pleistocene. Still longer periods are required for selection, for the development of new varieties, and for plant migration. The author postulates that Hohokam agriculture was already in existence by 0 A.D., and Basket-Maker culture by 300 A.D. He further argues that Middle American influences were felt in the Mississippi valley as early as 700 B.C., and agrees with Jones that the endemic eastern agriculture must have been developed by 2000 B.C.

ALBERT F. HILL

THE TEN GRANDMOTHERS. *The Civilization of the American Indian.*

By Alice Marriott. University of Oklahoma Press, Norman. $3.00. xiv + 306 pp. 1945.

The "ten grandmothers" are the ten sacred medicine bundles of the Kiowa, a Southern Plains tribe. Alice Marriott is an anthropologist, trained at the University of Oklahoma, and a very gifted writer. She spent ten summers with the descendants of the Kiowa, and had the good fortune to obtain detailed information from two very aged Indians whose recollections reached back into the 1840's of the last century. Instead of distilling her material into another conventional ethnographic monograph or editing it in the more or less raw form of the now so fashionable "life histories," she wrote thirty-three "true, short stories," centering around typical events in the life of the Kiowa during the time "when there were plenty of buffalo," "when buffalo were going," "when buffalo were gone," and "modern times," when buffalos live only in National Parks, Indians on reservations, and their young men work for WPA or have to leave for the white man's atomic war. The need to present anthropological material once in a while in a truthful but non-technical form has been felt ever since Elsie Clew Parsons edited her *American Indian Life*. Alice Marriott's short stories convey a most graphic and true impression of plains Indian life before and after the white invasion. At the same time they are real literary masterpieces, full of beauty and deeper meaning.

ERWIN H. ACKERKNECHT

THE PUEBLO INDIAN WORLD. *Studies on the Natural History of the Rio Grande Valley in Relation to Pueblo Indian Culture. Handbooks of Archaeological History. Edited, adapted, and amplified by Edgar L. Hewett and Bertha P. Dutton, with appendices by John P. Harrington. The University of New Mexico Press, Albuquerque.* $4.00. 176 pp.; 2 maps; 5 figures. 1945.

Among primitive people all over the world the Pueblo Indians of the Rio Grande Valley have always been one of the most fascinating groups to specialists and laymen alike. The result of this interest is an extraordinary amount of literature, mostly of very high quality, but mostly also widely dispersed in different scientific publications and coined in rather technical language, making rapid orientation for the non-spe-

cialist, even if he is an anthropologist, rather difficult. The idea of synthesizing and making accessible to a larger public such material in the form of handbooks, which at the same time maintain scientific standards, seems a most excellent one. The present handbook deals mainly with one of the fundamental aspects of the Pueblo Indian's life, his "world," that is his physical environment, as it is and as he sees it. Based mainly on technical treatises of their own, and of Castetter, Freire-Mareco, Harrington, Henderson, Miller, and Robbins, the authors give a very interesting and intelligible survey of the Pueblo Indian's knowledge and beliefs concerning the "geography" (stars, earth, streams, mountains, etc.) and the flora and fauna of the region. A second part of the book deals with the first impressions made by the Pueblos on white men, the Spanish explorers of the sixteenth and seventeenth centuries; and with the geology and geography of the region, also as seen by the white man. In an appendix, John P. Harrington publishes for the first time his important discovery of a "Pueblo-Aztecan" linguistic stock. The book is very useful, well written, on a high scholarly level, and most beautifully illustrated.

ERWIN H. ACKERKNECHT

OUTLINE OF CULTURAL MATERIALS. *Yale Anthropological Studies, Volume II. Revised Edition.*

By George P. Murdock, Clellan S. Ford, Alfred E. Hudson, Raymond Kennedy, Leo W. Simmons, and John W. M. Whiting. Yale University Press, New Haven; London: Humphrey Milford, Oxford University Press. $1.00 (paper). vii + 56 pp. 1945.

In pursuing their cross-cultural survey, Murdock and his colleagues have developed a classificatory scheme in which the fundamental traits of particular human cultures can be pigeonholed. This scheme embraces 45 main categories like language, family, technology, old age, war and peace, sex, etc., with numerous subdivisions. It is primarily destined to test cross-cultural generalizations, and to sift existing material on a given culture, in order to discover deficiencies and to direct corrective field work. This outline, resembling very much the old ethnological questionnaires and being probably more complete than any of them, can also serve similar purposes. For all its shortness, the little outline conveys a strong impression of the many facets and the complexity of human culture.

ERWIN H. ACKERKNECHT

ARCHAEOLOGICAL EXPLORATIONS IN JO DAVIESS COUNTY, ILLINOIS. *The Work of William Baker Nickerson (1895–1901) and the University of Chicago (1926–32). The University of Chicago Publications in Anthropology, Archaeological Series.*

By John W. Bennett. University of Chicago Press. $1.75 (paper). xiii + 168 pp.; 35 plates. 1945.

Material collected at the turn of the century and material collected by the University of Chicago in the late twenties and early thirties is here presented and analyzed. The early work was done with such unusual care that the field notes are of material use today. The combined materials give a considerable insight into the problems of the area. These center about the culture of the peoples building the mounds of this part of Illinois. A large number of mounds were examined, and their structure and contents were noted. Analysis of this information made possible a division of the mounds into two groups. Woodland and Hopewellian relationships are considered, and an attempt is made to fit the material into the general frame of eastern archeology.

GEORGE F. CARTER

ARCHAEOLOGY OF THE HOPEDALE AREA, LABRADOR. *Anthropological Papers of the American Museum of Natural History, Volume 39, Part 2.*

By Junius B. Bird. The American Museum of Natural History, New York. 85 cents (paper). Pp. 121–186; plates 9–12. 1945.

A series of Eskimo house sites in the Hopedale area of central coastal Labrador were excavated. The houses and the artifacts found are described. The presence of trade goods, the lack of much accumulation of midden material, and lack of evidence of much change in the culture through time, all point to a late and relatively brief occupance of the area by the Eskimo. The author thinks that the entrance to the area by the Eskimo may have been as recent as four hundred years ago.

GEORGE F. CARTER

THE ARCHAEOLOGY OF THE AUTLÁN-TUXCACUESCO AREA OF JALISCO. *I: The Autlán Zone. Ibero-Americana: 26.*

By Isabel Kelly. University of California Press, Berkeley and Los Angeles. $2.00 (paper). x + 98 pp.; 3 tables, 1 map. 1945.

This is a report on the archeology of the Autlán area, which lies on the western fringe of the high plateau in the southwestern part of Jalisco. The geographic setting of the area is briefly described, the early Spanish documents are utilized to furnish a background of the land utilization at contact times and to furnish some picture of the distribution of settlements. The use of the Spanish documentary sources has greatly enriched this study, for it has made possible a much more rounded picture of the culture of the people than would have been possible from the archeological re-

mains alone. Considerable effort is made to link the settlements mentioned in the sixteenth century documents with the archeological and still occupied sites.

Archeologically, three ceramic complexes can be isolated: Mylpa, Autlán, and Cofradia. Mylpa seems to be associated with the known sixteenth century settlements in El Chante valley. Autlán pottery seems to be associated with the sixteenth century sites of the Autlán valley. Kelly therefore postulates that Mylpa and Autlán complexes date from the time of the conquest, and that the Cofradia complex is earlier. Relationships to adjacent areas are noted, and the possible chronological implication is noted.

GEORGE F. CARTER

EXCAVATIONS AT CULIACÁN, SINALOA. *Ibero-Americana: 25.*

By Isabel Kelly. University of California Press, Berkeley and Los Angeles. $2.50 (paper). vi + 233 pp.; 6 tables, 1 map. 1945.

This is a report on archeological work in the central part of coastal Sinaloa in western Mexico. It is an area of considerable interest to students of the spread of higher cultures from Middle America toward the United States. Previous work in this area had disclosed the unexpected presence of high cultures showing relationships to the cultures of southern and central Mexico. This work adds materially to our knowledge of this culture, its cultural content, range, and chronology.

Pottery again proves to be the archeologist's most useful tool. The decorated wares provide design sequences which aid in placing the culture phases and in relating sites to one another. Other artifacts are also described, however. There is a particularly interesting appendix written by B. H. McLeod on the copper objects found. Microscopic examination by this metallurgical expert has yielded a fund of interesting information on primitive metal-working techniques. There is also an appendix by F. S. Hulse on skeletal remains. Bone preservation was poor, and skull deformation was practised, hence the material is not too satisfactory. Hulse concludes that on the whole the population seems to have been racially intermediate between the Mexican and the larger Southwestern types, with perhaps remnants of an older population akin to the Basketmakers.

The study leaves unanswered the problem of whence this culture came. Isabel Kelly is now inclined to abandon her previous hypothesis of a southern coastal origin in favor of some line leading from northern Nayarit into northern Jalisco. She states the problem as it now stands and suggests that our need now is for work in the western Sierra, in the so-called Tarascan culture. The study contains a wealth of well presented basic data which will be most useful to further students of the cultures in this area.

GEORGE F. CARTER

COSTA RICAN STONEWORK. *The Minor C. Keith Collection. Anthropological Papers of The American Museum of Natural History, Volume 39: Part 3.*

By J. Alden Mason. The American Museum of Natural History, New York. $2.75 (paper). Pp. 189–318 + 49 plates. 1945.

The stone work from the archeological collection from Costa Rica made by the late Minor C. Keith, beginning in 1872, is here presented. The material is described and illustrated. Keith, through his early appearance on the scene and his influential position, was able to gather an enormous collection. Unfortunately, he was neither a trained scientist nor aware of the value of records of finds. The utility of this unique and valuable collection is, therefore, somewhat limited. The author has so well stated the aims, limitations, and accomplishments of this work that we may well quote him:

> This monograph was intended as, and is primarily, a factual and visual report on a remarkable and unique collection from a region ordinarily not well represented in archaeological or art museums. The collection is extraordinary for the quantity and quality of the art objects and multiplies many fold the number of stone objects heretofore illustrated from this region. A fuller picture of the sculpture from the cultures involved is thus presented. From a scientific, archaeological point of view, its contributions cannot be great. It ignores the pottery, the archaeologists's best criterion for culture periods and contacts. It is accompanied by no excavation data. No deductions can be drawn from the absence of objects of any given type. Any conclusions, therefore, must be an attempt rather to place the cultures represented in their proper archaeological setting on the basis of known facts than to add greatly to the latter.

GEORGE F. CARTER

A CHINESE VILLAGE: *Taitou, Shantung Province.*

By Martin C. Yang. Columbia University Press, New York. $3.00. 275 pp. 1945.

The reviewer was born and passed his childhood and youth in localities of eastern Shantung within 100 miles of the village of Taitou that is the subject of this sociological study. Consequently, many things written here were familiar enough to arouse a long dormant nostalgia; others were new because of aspects of Chinese life always hidden from the foreigner; and still others were appreciated with that new and sudden illumination which occasionally strikes the long familiar scene when observed through other eyes. There are, not too oddly, also some features of his native life that would

at once impress the stranger which have escaped even the well-trained observation of the Chinese sociologist. Of these, more later.

The study is very well organized. It begins with descriptions of the village site, the people, their agriculture and their standard of living. While these differ locally in China, most rural villages in northern China, and particularly in Shantung, closely resemble Taitou, with its dependence upon wheat, millet, soybeans, sweet potatoes, and peanuts. The next section of the book considers the family, first as to its membership and the relationships within it, then as a primary economic group and as a primary ceremonial group. Marriage, child training, and the rise and fall of a family are specially considered. The third section takes up the village organization, conflicts within the village, and its leaders. Finally the relations of the village to the nearby market-town and to the city of Tsingtao are brought into clear focus. One of the most interesting chapters is the representative life-story of Tien-sze, who must clearly be the author himself. The objective way in which these personal incidents are woven into a sociological document is very fine. In conclusion, Yang forecasts the developing relations and inevitable changes in the village of tomorrow. He outlines a plan for redistributing the land that has great merit, although the disadvantage of having a big farm of the poorer land at a relatively great distance from the village, which would seem to follow from his plan, appears to have escaped him.

Yang's comments on marriage—the possibility of affection in arranged marriages and the advantages of difficult divorce—Americans will note with interest. On another subject liable to frequent misconception he should be heard: "Many people believe that China is a democratic country, but its democracy is of a negative sort. It is true that the villagers, after they have paid their taxes and fulfilled other occasional obligations, are almost completely independent of governmental administrations, and to this extent can be considered self-governed. But a closer view of the public life of the village shows it to be far from democratic. Local affairs have always been dominated by the village aristocracy, the clan heads and the official leaders. . . . By and large, the people have been ignorant, docile, and timid as regards public affairs."

To mention now a few points that seem to have escaped the author: He speaks of the importance attached to geomancy in selecting a site for a grave, but fails to tell why sealed coffins containing the dead are kept in the house up to a year, particularly in wealthy families. The importance of selecting a lucky *day* is quite as evident and significant as that of selecting the lucky *site*. Yang also fails to mention the heaping up of the conical grave mounds, so characteristic of the north China countryside, with their size varying in accordance with the wealth and importance of the deceased. Then, in discussing the crucial problem of land use and redistribution, he has ignored the astonishing proportion of the good land occupied by graves and the importance to be attached to the fact that the cemetery of each family is located on its own farmland. In a land where ancestral reverence is so potent, this is no minor matter. One more point relates to the bound feet of the women, a custom long since abandoned among Christian families, and now virtually disappearing among the younger generation of non-Christians too. It is hard to believe that so pervasive a change has avoided Taitou completely. The author's description is accurate in this respect for the days of his youth, but one might have expected so important a sociological change to have been noticed.

The book closes with two appendices, one describing farm implements, the other the elaborate system of kinship terms. One minor error has been found among the latter. There is an excellent index.

All criticisms must remain minor. The merits of the work are outstanding, and make this book not only an important contribution to rural sociology, but also an unparalleled source of general information regarding the Chinese people and their contemporary culture.

BENTLEY GLASS

TURKEY.

By Vernon Ives. Illustrated by Rafaello Busoni. Holiday House, New York. $1.00. 25 pp. 1945.

OCEANIA. *Hawaii, New Zealand and the South Pacific. By Charles A. Borden. Illustrated by Rafaello Busoni. Holiday House, New York.* $1.00. 25 pp. 1945.

These two small books form part of a series that deals with the geography and history of various countries or regions of the earth,—written for children of 12 to 16. The books are attractively printed and illustrated, with decorative maps as end-papers; they are also well written, and provide a good introduction to foreign lands and peoples. The book on Turkey emphasizes the history of the Turks, and their modernization under Kemal. The book on Oceania, including Hawaii and New Zealand, is more ethnological in treatment, and consequently is of more interest to young biologists and their teachers.

BIOMETRY

SAMPLING STATISTICS AND APPLICATIONS. *Fundamentals of the Theory of Statistics.*

By James G. Smith and Acheson J. Duncan. McGraw-Hill Book Company, New York. $4.00. xii + 498 pp.; 1 chart. 1945.

This is the second volume of *Fundamentals of the Theory of Statistics*, the first volume, *Elementary Statistics and*

Applications, having been published in 1944. A table of symbols and a chapter reviewing some of the basic concepts and definitions developed in the first volume are presented at the outset, so that this volume is self-contained. The subject matter of the book is then presented in three parts, each divided into five or six chapters, these parts being titled: General Theory of Frequency Curves; Elementary Theory of Random Sampling; and Advanced Sampling Problems. An appendix contains 14 tables.

Statistical theory in this field is so extensive and is growing so rapidly that the problem of selection for presentation in a single volume is not easy. Since, under the general titles of the three parts, different statisticians would discuss quite different topics, a description of the selection the authors have made here is necessary.

Part I discusses the concept of mathematical probability in terms of the relative frequency in a set of objects, leading to the symmetrical binomial distribution and the normal curve. The Pearsonian and Gram-Charlier systems of curves are then derived and applied, and certain special distributions, the t-distribution, χ^2-distribution, and F-distribution are presented as examples of non-normal distributions, without at this point including a consideration of their relation to sampling theory.

Part II deals first with the concept of sampling, particularly from the point of view of drawing inferences about the population from the sample, and then presents specifically the problems of random samples from a two-fold population, samples from normal populations, as to distribution of mean, median, variance, standard deviation, average deviation, and range. A brief discussion is also given on sampling fluctuations in correlation statistics. In these problems consideration is given to testing hypotheses, setting up confidence intervals and making optimum estimations.

Part III presents problems of sampling from a discrete manifold population, joint sampling distributions of the mean and standard deviation, regression statistics, the comparison of two samples, and an introduction to analysis of variance.

Throughout the book the assumptions on which the theory is based are stressed, and the limitations which these impose on the application of the theory in practical problems are considered. Derivations of much of the theory are presented, at times as an integral part of the discussion, at times as appendices to the separate chapters.

This book pulls together a great deal of material which is scattered through the literature and presents it in a clear and convenient way. It is much more comprehensive on the subject of sampling than the majority of statistical text-books available, and on the whole the selection of topics is good. It would seem likely to prove to be a very useful book for both teaching and reference.

With regard to the section on frequency distributions, it seems regrettable that the method of transformation of the variable is not included, since it is one of the most useful and simple methods available. It is not mentioned in this section, although reference is made to it in the last chapter of the book under "Indirect Attacks on the Problem of Non-Normality." Here it is stated that in certain cases the logarithmic transformation of the normal curve may readily solve the problem of non-normality. This approach is not developed, however. In the earlier section on frequency curves, a distribution of weights of Princeton freshmen is fitted by both the Gram-Charlier curve and the Pearson Type VI curve with rather unsuccessful results, so that it is concluded: "Apparently, owing to the sharp peak in the center, the given data cannot be well fitted by a smooth curve" (p. 152). This sort of statement is always dangerous, and in the present case, the logarithmic transformation of the normal curve gives an excellent fit, and is a simpler curve, as to number of constants, than either of those used.

In a number of places in the book, percentages are used as if they were proportions or probabilities, and on p. 190 this leads to an erroneous formula for β_2 in the point binomial, since the formula as quoted is correct if p_1 and p_2 are probabilities, but not if they are percentages, as stated.

There is no bibliography, but there are frequent footnote references to original papers. These are not, however, as numerous as one would like. Student, for example, does not appear in the author index, which seems a rather serious omission in a book written under this title. A bibliography at the end of each chapter would be a distinct addition.

More than balancing the points of disagreement with the presentation which have been mentioned are the many features of the book which recommend it. These include the statement of assumptions, the inclusion of derivations where possible, and the directing of attention to abbreviations and omissions in the mathematical argument where necessary. It is emphasized that problems of sampling are more than testing hypotheses but pertain also to getting observations and to making estimates from them. The book should be very useful to students who are finding out what sampling is all about, as well as to more advanced students who will undoubtedly appreciate having so much of the material brought together in one place.

MARGARET MERRELL

TABLE OF ARC SIN X.

Prepared by the Mathematical Tables Project conducted under the sponsorship of the National Bureau of Standards. Begun under auspices of the Work Projects Administration for the City of New York and completed with the support of the Office of Scientific Re-

search and Development. Columbia University Press, New York. $3.50. xix + 121 pp. 1945.

TABLES OF ASSOCIATED LEGENDRE FUNCTIONS.

Prepared by the Mathematical Tables Project conducted under the sponsorship of the National Bureau of Standards. Begun under auspices of the Work Projects Administration for the City of New York and completed with the support of the Office of Scientific Research and Development. Columbia University Press, New York. $5.00. xlvi + 303 pp. 1945.

These are tables 17 and 18 respectively of the Mathematical Tables Project which was started under the Work's Projects Administration and is being continued under the sponsorship of the National Bureau of Standards under the direction of Dr. Arnold N. Lowan. The Project has had the policy of selecting for tabulation, functions of fundamental importance in pure and applied mathematics, and its directors have worked in close cooperation with the mathematicians and physicists in their planning and preparation of the tables.

The first of the present tables gives, to 12 decimal places, values in radians of Arc sin x; it may also be used to obtain values of Arc cos x. The values are tabulated at intervals of 0.0001 in the range between 0 and .9890 and at intervals of 0.00001 in the range between 0.98900 and 1.

The second table, of Associated Legendre Functions, is one which has been needed by engineers and physicists in a number of their problems. In fact, the table has been sufficiently in demand to bring about its publication at the present time although further tabulation of these functions is planned by the Project. The interval in the argument is not small enough everywhere in the range to allow satisfactory interpolation, but it is proposed to publish as a supplementary volume at a later time, the finer tabulation of the functions.

The excellent quality of the work of this Project is now well-known and these additions to the series are welcome.

MARGARET MERRELL

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE LIFE HISTORY OF AN AMERICAN NATURALIST.

By Francis B. Sumner. The Jaques Cattell Press, Lancaster. $3.00. vii + 298 pp. 1945.

This is a very strange book. I picked it up with great interest, for Sumner's work on *Peromyscus* has my profound respect. There is a disappointingly minor consideration of that scientific achievement here, however. Instead, one finds the self-confessions of a socially maladjusted spirit. Prejudice and bitterness warred with idealism and scientific balance in his mind. A strange reticence that hides the name of some long-forgotten intolerant professor or autocratic superior contrasts with the frank and revealing portrait of some family member or friend. Sumner was disconcertingly modest about his scientific achievements and inordinately vain about his literary abilities, which hardly seem extraordinary. He briefly dismisses the accounts of his experimental work to inveigh against "boosters" and anti-vivisectionists or conventional religion. His approval of British harshness and brutality in dealing with the natives in the Sudan, on the ground of their racial inability to understand milder measures, is strangely incongruous with his sympathy for the weak and the under-dog. His view that the Jews are a "racially distinct group"—"be it gross or subtle, the difference is a biological one, and one which rests upon a genetic basis"—is certainly not scientific, even though it may be "straight talk." It will not help to allay prejudices to attribute to heredity those traits which most anthropologists are convinced are cultural.

There is much of interest in this life. Certainly no criticism of the reviewer could exceed Sumner's own biting, savage self-criticism at times. The roots of this long self-enmity seem to go back to his childhood, to his brilliant, erratic, and unsuccessful father, to his uncomprehending mother, to his afflicted sister. He grew up starved for affection, an Ishmael among other boys; and of him it may be said, as he said of his patron E. W. Scripps, "He was a man who defied classification according to conventional human standards." That he was a worthy scientist and achieved much is the more to his credit.

BENTLEY GLASS

OPTICAL INSTRUMENTS.

By Earle B. Brown. Foreword by James G. Baker. Chemical Publishing Company, Brooklyn. $10.00. xii + 567 pp. 1945.

The author states that this book "has been written primarily for the individual who comes in contact with optical instruments as a student, operator, teacher, engineer or repairman. It is not intended for the optical or mechanical engineer, nor as a manual of instruction for the use and care of any instrument." In such a book it is necessary to spend much space on simple matters, to omit thorough discussion of complicated ones, and to write in a descriptive rather than in an analytical manner. In this case, unfortunately, the attempt has resulted in excessive elaboration of elementary detail in some parts and mere superficiality in others.

In Part I, "Principles of Geometrical Optics," the laws of reflection and refraction are treated with a formality reminiscent of a high school text in plane geometry. The familiar formulae for magnifications, relations of conjugate distances for thin and for thick lenses, and other first-order characteristics are devel-

oped in considerable detail. This formality is almost entirely unrelieved by examples, and the reader not already familiar with geometrical optics must wonder what benefit is to be obtained from wading through much of it. The chapter on total reflecting prisms may be useful to persons who find it necessary to use such prisms in experimental instruments so as to produce properly oriented images.

The second part, "Description, Operation and Theory of Optical Instruments," attempts to describe some fifteen or twenty widely different instruments. It is in this section that the elaboration of simplicity and the superficial treatment of important matters are most noticeable. A person moderately familiar with the use of a microscope, for example, would find little to interest him in the chapter on this instrument.

The third section, "Construction and Maintenance of Optical Instruments," contains helpful suggestions, but a person in a position requiring application of the suggestions should receive much more thorough instruction than is given here.

A fourth part contains a few supplementary topics. An appendix on mathematical proofs and a glossary of optical terms complete the book.

A volume of this sort should at least be a reliable reference book for the subjects it discusses. The loose statements, half truths, and errors in the present work make it extremely unsatisfactory for use by a novice. On page 276, for example, we get the impression that achromatism of a projection lens is less important for black-and-white than for colored objects. On page 280 we find reference to the condenser in an opaque projector, though most manufacturers, at least in this country, have abandoned that form of construction. On page 240, *wide field* eyepieces and *high eye point* eyepieces are considered to be identical. On page 247, we are told that an iris diaphragm of a microscope lamp is to be used to control the intensity of illumination; this is a particularly reprehensible practice.

An outstanding feature of the book is the poor quality of the illustrations. Even complete instruments, of which good photographs could have been easily obtained, are illustrated by crude drawings. Diagrams of mechanical subassemblies are very hard to interpret. Optical layouts and the diagrams used in mathematical proofs contain glaring errors. In Figure 19, intended to show total reflection, angles I_1' and I_2 are drawn equal, though I_2 should be considerably greater than I if the ray is to suffer total reflection. In Figure 167, the object on the stage of the comparator apparently exerts a converging effect on the rays of light.

It seems likely that a person sufficiently interested in the subject of optical instruments to pay the considerable price of this volume would want a book more informative and more reliable.

A. J. KAVANAGH

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY *Held at Philadelphia for Promoting Useful Knowledge. Volume 89, Number 4.*

The American Philosophical Society, Philadelphia. $1.00 (paper). Pp. 543–628. 1945.

This number of the *Proceedings* contains three papers of interest to biologists: Removing Some of the Barriers to Crossability in Plants, by Albert F. Blakeslee; Inheritance of Factors Involved in One Type of Heterocaryotic Vigor (*Neurospora*), by B. O. Dodge, Mary B. Schmitt, and Anita Appel; and The Numbers of Vertebrae in Primates, by Adolph H. Schultz and Wm. L. Straus, Jr.